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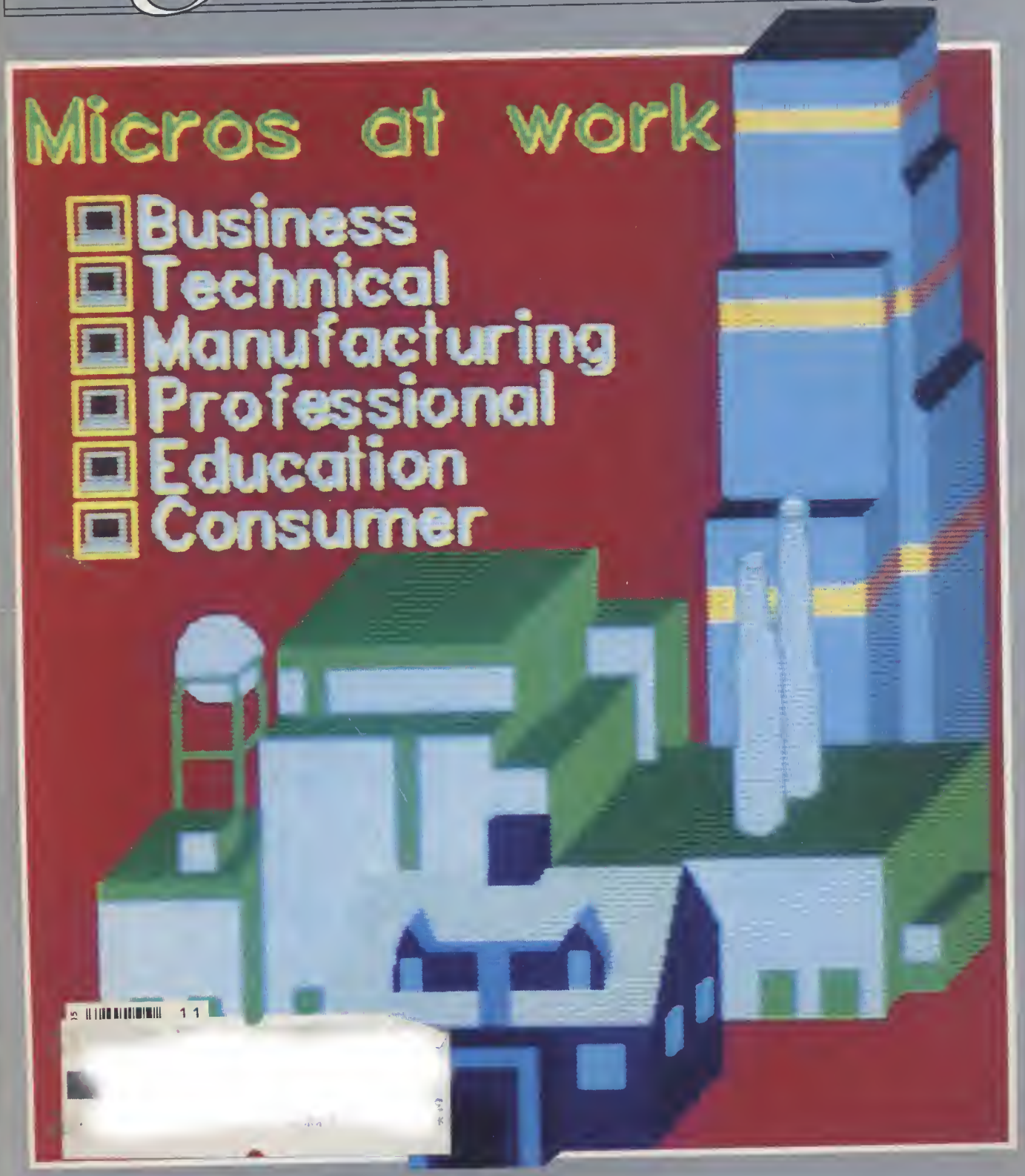

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FEATURES

DEPARTMENTS

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DAVE RIDLEY

National strength comes from people who work, leaders who lead

The United States is a case study in freedom. It serves as a beacon to the world, demonstrating how a democratic and open society can generate innovation and economic success through the creative energies and hard work of its citizens.

But too many Americans, having grown comfortable and complacent while enjoying the fruits of their ancestors' labor, no longer see the need to work hard, to struggle to excel, or to build new paths to the future. To them the work ethic is a joke, the conscientious worker a fool. They ask, "What's in it for me?"—not "How can I make a stronger contribution?"

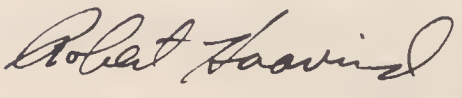
These attitudes can be found up and down the corporate ladder. Top executives too often generate quarterly profit increases through accounting chicanery rather than through well-planned business strategies. Middle managers who play corporate power games get ahead by bamboozling top management rather than by organizing effective departments. And many workers are more concerned with not doing "other people's work" than with making good products or giving good service, and thus helping to build a successful enterprise.

Still, there are some bright spots. The U.S. continues to be a haven for wave after wave of immigrants looking for opportunity and willing to work hard to earn it. And the innovative spirit is still alive at thousands of technology start-ups—in Silicon Valley and in dozens of other developing regions around the country—as well as in many universities and industrial laboratories.

Unfortunately, the leadership needed to keep the American economy strong has been sadly lacking in recent years, through administrations from both major parties. Despite swollen federal budgets, real problems have steadily worsened while powerful lobbies have been able to bend the political process to their own purposes.

There is a critical need for innovative leadership, at the national level and in the business community, to nurture emerging industries, reshape troubled ones, and provide the statesmanship necessary to avoid devastating conflicts with other nations. We need vision and imagination to continue to prosper in a future of rapid change and fierce international economic competition.

No inviolate law says that the U.S. economy has to remain the strongest in the world. Getting to the top takes hard work. So does staying there. Others who are willing to work harder and smarter—if only by borrowing ideas from our open society—will eventually pass us.



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LETTERS

Losing ground in ceramics

Thirty years ago American industry trained the Japanese to manufacture products in Japan in return for technical fees and royalties. Many of us involved in that effort were curious and concerned about its future impact; nevertheless, as a young ceramic engineer, I contributed to the fact the Japanese are now "Marching into the New Stone Age" (Aug. 1985, p. 50). We trained Japanese technicians to produce special refractories, for example, from the very materials with which they now profess to be "pioneers in the technology."

Apparently we had some cause for concern. The United States has now stopped producing as it had and has allowed others to catch up and get ahead. Unless we as a nation recognize the urgency of the situation and take back full control of our technical destiny, we will certainly lose it altogether in a lot less than thirty years.

Duncan C. Morrison
Burnsville, Minn.

A question of vulnerability

"Zapping missiles in space" (Aug., p. 72) claims that "particle beams of relatively low intensity could destroy a missile's electronic control and navigation systems." Usually these systems are packed in metal boxes several hundredths of an inch thick and then put inside sturdily built rockets, thereby making them invulnerable to such attack.

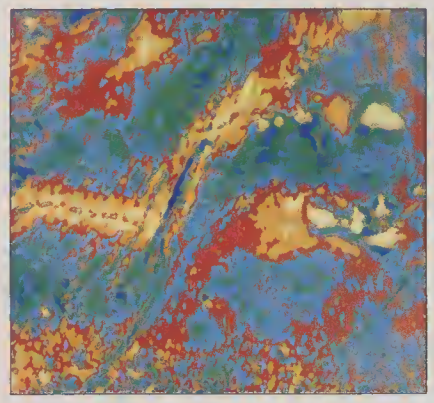
Also, the boost phase rockets mentioned are not vulnerable just because they are under stress; they are built to take stress.

David A. Lloyd-Jones
GML Computer Systems
Toronto, Ont.

Gravity makes waves

As a marine geophysicist specializing in acoustic exploration methods, I found "Cold war in the ocean depths" (July, p. 29) quite interesting and, for the most part, very accurate. However, the explanation for the topographic content seen in the SeaSat satellites' synthethic-aperture radar (SAR) data is not quite correct. The topography's principal effect is derived from the density contrast between the water and the underlying crustal material. The gravitational attraction between a seamount and the surrounding water, for example, results in a local elevation of sea level by as much as several meters. The derivative of the sea level, or geoid, yields the local value of the gravitational field.

John B. Diebold
Palisades, N.Y.



Different colors in this SeaSat radar image of the ocean surface (south of Africa) represent variations in sea level. These variations are caused by uneven gravitational pull from ocean-floor topographical features.

File conversion services

I enjoyed the article "File-transfer headaches—and cures" (Sept., p. 54); it is the best general overview of the topic I have seen anywhere. I would like to add one more cure: There are several service companies that have selected the best equipment mentioned in the article and have added software and expertise to improve the conversion process.

For those who need to convert text files from one computer system to another but cannot afford a $10,000–$50,000 investment, these service bureaus are probably the best choice. The charge for converting a disk is typically $20–$60.

Mark Gross, President
Data Conversion Laboratory
Fresh Meadows, N.Y.

Britain and jump jets

As an aviation enthusiast and active amateur pilot I must take exception to the statement in "Supersonic jump jets" (Sept., p. 38) that McDonnell Douglas and British Aerospace collaborated in the development of the Harrier. The author neglects to mention that the Harrier airframe and its engine were developed entirely in the United Kingdom by Hawker Siddeley Aircraft and Bristol Siddeley Engines.

After much persuasion by the Marine Corps and following a year of negotiations with two other U.S. companies (Grumman and Chance-Vought), Hawker Siddeley finally awarded McDonnell Douglas a license to manufacture the Harrier in the United States in late 1969, several months after the introduction of the aircraft to Royal Air Force service.

David Gwynne
Brampton, Ont.

Your otherwise excellent article on supersonic jump jets implies that today's vertical/short takeoff military aircraft make large carriers unnecessary. But the premature decision to scrap its large carriers cost Great Britain several warships in the Falklands. That's why the aerial dogfights in the Falklands took place over the British Fleet instead of 150–200 miles away.

James A. McClure
Oak Park, Il.

Editor's note: Naval strategy based on jump jets is to keep large carriers and the main fleet far offshore while small carriers move in close to the action to service V/STOL fighters. This would make the main fleet less vulnerable.

Tomorrow's trucks

"The truck of the future," (June, p. 28) was not futuristic enough. It focused on modifications to current trucks to make them competitive through 1990, and barely touched on design and materials for long-haul trucks of the 21st century. Where was the discussion of active suspension or advanced composites?

F. Hiscock
Columbus, Ohio

Editor's note: In "Modem madness" (Oct.) two addresses were inadvertently omitted:

Datran, 10519 Lauriston Ave., Los Angeles, CA 90064, (213) 474–3684

Spectrum Cellular, 2710 Stemmons Fwy., 800 North Tower, Dallas, TX 75207, (800) 233–2119

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA, 02110.

OFFICE AUTOMATION: HOW MUCH IS TOO MUCH?

Sometime last year American business crossed a technological Rubicon. For the first time in our history, capital investment per office worker exceeded that per factory hand.

Like it or not, information has finally surpassed material goods as our basic resource.

Walter Wriston, ex-Citicorp chief, likens information to a new form of capital, one that is arguably "more critical to the future of the American economy than money capital."

Every day brings news of faster, smaller, more capable devices to serve the 70% of us who now work with this new form of capital.

But while the trend spotters on

continued on next page

continued from preceding page

their mountaintops cheer this "Second Industrial Revolution," the view from the front lines is not so rosy.

Too often, new devices are an uneasy fit with their sister machines of just a year ago. Too often, systems intended to simplify office life have the opposite effect. Grouses one manager: "The more business machines we buy, the more we seem to need."

Change is rampant. The stakes are high. Confusion is king.

RASCALS. The best way to make sense of all this technology may be to ignore the whole business for a week or so and think about how your office works instead.

Who uses what kind of information? Where does it come from? What do they do with it?

No company on earth has pockets so deep that it can afford to automate every aspect of its business. Some hard choices lie ahead.

Item: In a typical office, 75% of the salary dollars go to managers and professionals. The system that spares these expensive rascals from a morning meeting or an hour of returning phone calls may be a better investment than one that does a whole day's work for someone else.

Item: The lion's share of time spent in any office is spent *communicating:* listening, talking, chasing down stray facts, dealing with mail.

Were you to keep a log, you'd be appalled by how little time you have for actually producing "work." (Par for senior executives: about 15%.)

To leverage time, look for ways to *move* information more efficiently.

A desktop computer can perform in minutes the spreadsheet analyses that used to gobble hours. But how much is gained if the figures still walk from office to office in a mail cart?

Item: Streamlining the internal workings of your office may be less profitable than automating ties with customers or suppliers.

Japanese style "just in time" deliveries from suppliers are helping U.S. automakers slash inventory costs. Computerized flight information systems have given some airlines a strategic advantage with travel agents.

No company succeeds alone.

BALANCE. Complicating the question of where your systems dollar is best spent is where you spent it last time out. And the time before that. A lot of past choices are coming back to haunt today's manager.

Reason: most of the systems clicking away in offices today were purchased a la carte – when phones were phones, computers were computers, and "office automation" meant word processing and copiers.

Now the walls between these separate technologies are tumbling down.

Some office telephone systems can now process data. Computers have evolved that can communicate.

It's dawning on customers and vendors alike that the future belongs to

No company on earth has pockets so deep that it can afford to automate every aspect of its business. Some hard choices lie ahead.

Today's customer must strike a balance between making the most of what's on hand and fighting like crazy to keep next year's options open.

the *integrated* business system.

Today's customer must strike a balance between making the most of what's on hand and fighting like crazy to keep next year's options open.

MISSING LINKS. Between today's a la carte systems and the office-wide, integrated everything of tomorrow is . . . what?

For many companies, the missing links are *networks.* By permitting different kinds of computers and other devices to share information, networks can pull today's stand-alone business machines into organized "islands" of automation.

Since these islands themselves can be networked together, users can widen the scope of automation in an organization pretty much at will.

Some companies have the backbone of an *office-wide* network already in place. Today's digital telephone switching systems (PBXs) convert speech into the same "bits" and "bytes" that computers use.

This means that many an existing telephone network can double as a highway for business data — and that "office automation" need have no geographic limits.

A plug for the home team: Every vendor does some things better than the other guys. While communications and data networks are drawing-board doodles in some shops, they are bread and butter items at AT&T.

It may be AT&T's greatest strength that we can integrate new and existing systems whether we provide *all* of those systems, or *some* of those systems, or the bridges between them.

SUCCESS. Like the first Industrial Revolution, this one will lift some companies and confound others.

Those without a coherent plan to manage information in *all* its forms — the spoken word, thoughts on paper, images, and computer data—will be at a disadvantage.

In the long run, your success with office automation will have less to do with whose machines you buy — or how many — than with how freely information travels among them. It is the relationships you set up *between* the machines, not the devices themselves, that will tell the tale.

P.S. Much of this message was drawn from *The Integration Puzzle,* a two-day seminar offered by AT&T's Institute for Communications and Information Management. For further information or for a catalogue of AT&T Seminars in eight cities, please telephone 1 800 247-1212.

Or write Mr. Dale Hegstrom, AT&T Information Systems, P.O. Box 1405, Morristown, NJ 07960-1405.

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UPDATE

How information technology affects business

MIT's Sloan School of Management has kicked off a five-year, $5 million research program to study the effects of computers and telecommunications on managerial practices, organizational structures, and business strategies. Called "Management in the 1990s," the program will conduct its investigations through case studies of numerous firms and organizations.

The study is funded by nine corporations (Digital Equipment, British Petroleum, International Computers, Eastman Kodak, Arthur Young and Co., MCI Telecommunications, Bell South, General Motors, and American Express) and the Internal Revenue Service. Corporate and government contributions are, in effect, "buying early insight into project results," says Deputy Dean Alvin J. Silk. Later, as research progresses, program administrators will publish working papers and a quarterly newsletter.

Initial studies cover a wide range of topics, including how businesses are adapting to personal computers, how manufacturers are changing factory work flow, and how top executives are learning to use computerized decision-making systems. The IRS, for example, will be the guinea pig for a study on the use of microcomputers.

Magnetic resonance analyzes heart tissue

Magnetic resonance (MR) was recently used for the first time to produce a chemical "portrait" of living tissue. The result could be an entirely new, noninvasive means of assessing abnormal physical conditions.

GE's Bottomley examines magnetic resonance spectra showing phosphorus levels in a normal heart. On screen is an MR image of the same subject's heart and other organs.

Using a form of MR called depth-resolved surface coil spectroscopy, Paul A. Bottomley, a physicist at General Electric's R&D Center in Schenectady, N.Y., analyzed several phosphorus compounds in a healthy heart. As in the closely related technology called MR imaging, which provides detailed pictures of internal organs, the compounds are excited from outside the body with magnetic and radio waves; as the atoms return to their normal energy state, they emit electromagnetic signals. But instead of converting these signals into pictures, the spectroscopic method produces characteristic curves, or spectra. Many researchers are convinced that the technique can one day be used in medical diagnosis, since the spectra of abnormal tissue are substantially different from those of healthy tissue. After a heart attack, for instance, levels of the chemical phosphocreatinine fall, while those of inorganic phosphorus rise.

Bottomley obtained his results with a five-ton superconducting magnet, produced by GE, that generates a field of 1.5 tesla (about 30,000 times as strong as that of the earth).

Touch-screen graphics hits the road

A touch-operated instrument screen is now appearing for the first time in a U.S. production automobile. Driven by an 8-kilobyte microprocessor, the Graphic Control Center in the 1986 Buick Riviera handles more than 100 control functions. Touching the screen brings up menus for climate control, trip calculations, engine diagnostics, radio and tape-deck operation, and instrument displays.

Each category has several "pages" of controls or readouts. For example, the trip monitor function has a page that estimates arrival time; the driver enters the distance to destination, and the system makes calculations on the basis of average speed over the last 5–10 miles. Another page shows fuel consumption and gas mileage since the ignition was switched on.

The driver needn't worry about remembering to switch the system on and off. It starts to warm up when the driver's door handle is touched, and it brings up the display as soon as the door is closed. Power shuts off again shortly after the ignition is switched off.

Engineered hormones make salmon grow faster

Fish farmers may soon be netting the benefits of a new biotechnology application. In a recent study by Canada's Department of Fisheries and Oceans (West Vancouver, B.C.), juvenile salmon injected with genetically engineered growth hormones grew up to 50% faster than normal. Researchers gave the fish weekly injections of chicken and bovine growth hormone, manufactured in bacteria by Amgen (Thousand Oaks, Cal.). After six weeks, the fish receiving the highest hormone doses weighed 50% more than untreated controls and were 20% longer. A dose one fifth as high increased weight about 20% and length 10%.

WILLIAN BOEHM/WEST STOCK

Salmon injected with growth hormones stand a better chance of returning to the spawning grounds.

Because the hormone treatment increases the salmon's ability to convert feed into tissue by a third, it could substantially reduce the costs of salmon aquaculture. At present, hatchery-grown salmon—which are released into the ocean while still small—take about three years to reach maturity, and only about 3% return to the hatchery for spawning and harvest. Researchers believe that if the fish were larger when released, their chances for survival and return would be much greater.

The use of genetically engineered growth hormones is applicable to other fish that are raised commercially, such as catfish and trout. Amgen estimates that the potential market for aquaculture-related growth hormones is now $10–50 million.

Linking the factory and the office

A critical step toward true computer-integrated manufacturing (CIM) is being taken this month with the demonstration of the first working link between factory- and office-automation networks. At Autofact '85, a manufacturing automation trade show in Detroit's Cobo Hall, General Motors and Boeing are joining forces in a quarter-acre exhibit that will have a working network linking equipment from 25 different vendors.

One side of the exhibit will resemble a small factory, with a variety of robotic and numerically controlled devices linked to computers and terminals via GM's Manufacturing Automation Protocol (MAP). The other side of the exhibit will contain an engineering design office with workstations networked by Boeing's Technical Office Protocol (TOP). The two networks will be linked with a broadband 10-megabit-per-second coaxial cable using the internetworking facilities of MAP.

MAP was developed by GM as an internal specification for its manufacturing divisions. According to GM, some 300 other firms are experimenting with the protocol, and more than 30 vendors of automation equipment are studying ways of making their products compatible with it.

The first plant to link all of its machinery with MAP will be GM's Saginaw Steering Gear Division factory in Saginaw, Mich., with a network of about 40 manufacturing cells due to start operation later this year. Full integration into a factory control system and the plant's CAD/CAM system is planned for 1987.

Compact synchrotron will allow denser chips

The Japanese plan to develop a compact synchrotron particle accelerator that will produce x-rays for making high-density integrated circuits. Nippon Telegraph & Telephone (NTT) is working with a team of semiconductor makers, including Hitachi and Toshiba, on research that could lead to a practical model in 4–5 years.

Synchrotron radiation—powerful emissions produced when electrons or protons are accelerated along a curved path by a magnetic field—can be tuned to any frequency from infrared to high-energy x-ray. In the x-ray region, synchrotron beams could be used to expose photoresists for very-large-scale integrated circuits with line widths of 0.5 micron or less. (Today's advanced circuits, such as 256K RAM chips, have line widths of about 2 microns). Currently, such radiation must be tapped from huge accelerators used for physics experiments. The planned compact source would be about 10 meters in diameter. Costs for developing the synchrotron and installing it at NTT's Atsugi laboratories are estimated at $20–40 million.

The project is also drawing on the expertise of Japanese companies that make pumps and other components for accelerators.

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Engineering research and international competitiveness

by Roland W. Schmitt
Senior Vice-President, Corporate R&D
General Electric

Fundamental scientific knowledge is one of America's most effective forms of foreign aid. Unfortunately, it's foreign aid for our strongest rivals. The Japanese, for example, appreciate our research efforts so much that their industries spend two and a half times as much money funding university and nonprofit research laboratories outside their own nation—mainly in the U.S.—as they spend on such laboratories at home. And Japan pays us nearly ten times as much on patent licenses and other forms of technology imports as we pay them. That favorable balance of trade in intellectual property more than doubled in the 1970s, the decade when all other balance-of-payments figures with Japan were moving in the opposite direction.

These numbers challenge the assumption that doing more of our own research will improve our international competitiveness. Japan's experience shows that it is possible to succeed technologically while relying on others for fundamental knowledge and new ideas. But instead of rushing off to blindly imitate Japanese methods, we might formulate better ways of directing and using our own research.

Perhaps we're doing the right kinds of basic research, but making it too easy for our international rivals to get their hands on the results. The apparent cure would be to put controls on the movement of our basic research results across international boundaries. But such a policy would be shortsighted. Any conceivable method of slowing down the flow of fundamental ideas between us and our competitors would severely damage our own creativity.

A second possibility is that our government might be overinvesting in basic research and underinvesting in applied research. The cure would then be to adjust the focus of our national research effort. This would also be shortsighted. Government must not turn from a job it does well (supporting basic research) to one it does poorly (trying to anticipate markets in areas where it is neither a consumer nor a producer).

I believe that a third conclusion is most appropriate. We must build upon, rather than abandon, one of our greatest strengths: our fundamental research capability. But we must also make sure that we put our scientific knowledge to use more quickly than others do. We've got to increase our efforts in engineering research—the link between fundamental scientific research and application.

The middle ground between science and engineering, where the leading edge of research meets the cutting edge of application, is becoming more critical than ever before. In fields such as computer-integrated manufacturing, communications systems, very-large-scale integrated circuits, advanced engineering materials, artificial intelligence, supercomputers, and biotechnology—where international competition is beginning—the strengths of engineering researchers will especially be needed.

But although we need stronger and wider bridges between the people doing engineering in industry and the people teaching engineering and doing research in universities, we have not paid enough attention to designing and building those bridges. Engineering researchers have traditionally come to their trade with little encouragement from the government, and few emerge directly from the graduate schools.

In some ways, engineering researchers resemble the Shakers—the religious sect renowned for its fine furniture and practical inventions—who thought procreation a sin. Engineering researchers similarly fail to regenerate themselves, although more as a matter of circumstance than of morality. Young engineers are typically trained in conventional engineering programs, and even those headed for careers in engineering research are rarely exposed in school to the kinds of working conditions or professional relations they will later encounter. In contrast, scientists are usually trained in laboratories very much like those in which they will later work.

So there is not only a gap between the generation of knowledge and the application of knowledge but also a gap between the apprenticeships of potential engineering researchers and the roles they will eventually fill.

In the past, we have relied on chance to produce engineering researchers, and have made no concerted effort to create institutions that focus on engineering research. We are now designing such institutions at our universities, of which the Engineering Research Centers are noteworthy examples. These centers, to be established initially at six universities, will focus on areas of technology—such as robotics, microelectronics, telecommunications, composite materials, artificial intelligence, biotechnology, and computer-integrated manufacturing—that are crucial to the future of U.S. industry. They will be supported by the National Science Foundation, which will provide $94.5 million in funding over the next five years.

We often hear that these centers will be distinguished by three principal features: industrial support, interdisciplinary scope, and research aimed at utility. These descriptions are correct, as far as they go, but they miss the essence. "Industry support"—the bridge established between universities and industry—should carry much

more than dollars. As one university president put it: "Don't just send us your money, send us your critical problems and people who understand them." And sending problems does not mean sending applied research problems. The idea is not to create job shops for industry but to do fundamental research in the areas of engineering practice being taken on by industry. The centers should not be building factory robots, for example, but generating new understanding of the fundamentals of robotic vision, touch, and control; not programming expert systems for use in diagnostics or repair, but acquiring new understanding of knowledge representation and developing the fundamentals of artificial intelligence; not building biotechnology production facilities, but devising new unit-operations concepts for biological processes.

The goal of industry–university interaction should be a two-way flow of information. From industry to universities should flow understanding of the barrier problems that practice is running into. From universities to industry should flow the knowledge and talent needed to overcome the fundamental problems. The main point is not to drive universities away from fundamental research but to orient them toward the areas of fundamental research that are most needed by industry.

The second important feature of the Engineering Research Centers is their cross-disciplinary nature. But let us strenuously avoid creating just another interdisciplinary program, which more often than not simply means a collection of specialists in different disciplines sharing a roof or a secretary. We need organizations whose shape is dictated by the problem to be solved or the type of result needed, not by the disciplines involved.

I'm under no illusions about the difficulty of realizing such a goal. The problem-solving culture of engineering practice is coming up against the disciplinary culture of engineering science. There will be mutual suspicion and resistance to change, just as there always is when cultures clash. But this interaction of cultures can actually strengthen the disciplinary base. Programs that transcend disciplines can enhance the excellence of disciplinary research both by revitalizing established fields and by creating new ones.

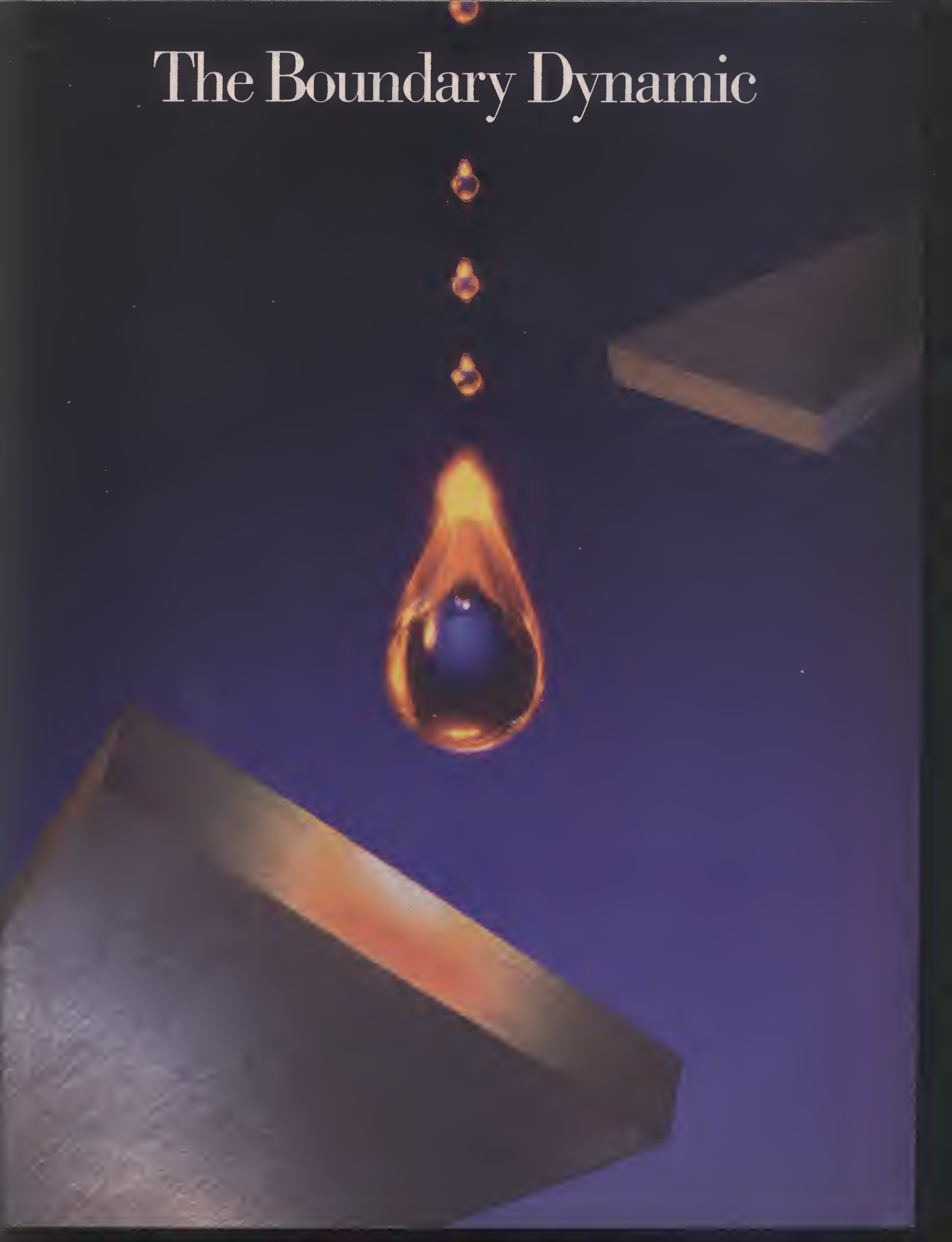
Finally, and most difficult of all, let's not take too narrow a view of the connections between engineering research and innovation. We must embed engineering research in the total process of innovation—from identifying the market all the way through production, quality control, maintenance, and improvement of the first product into a commercial success.

Moreover, these parts of the innovation process can't be separated into watertight compartments. The separation of marketing and engineering has killed many promising innovations in their early stages. Typically, the marketing people don't know enough about the future possibilities of the technology to ask the right questions of the users, and the technologists don't know enough about the users to make the right demands of the technology. For similar reasons, the separation of engineering and manufacturing can be just as fatal.

Building this total process awareness into the work of the new institutions should reflect the spirit of the late George Low, president of Rensselaer Polytechnic Institute and a pioneer of the Engineering Research Center concept. To train engineers, he believed, it wasn't enough just to put them to work in the classroom and the laboratory. They also had to experience the frustration and the excitement of putting advanced technology to work. In a program at RPI involving composite materials, for example, the students conceived of a product concept—a glider made of new composites—and immersed themselves in all the difficulties involved in getting a product out the door. As the final exam, they were required to test-fly the glider themselves! The glider flew, and so should the philosophy behind it. The Engineering Research Centers should get students used to the idea that the engineer does research in order to do, not merely to know.

Let's create a golden age for engineering research by designing such centers to forge links with industry that carry not only money but also the practical barrier problems that inspire research; to be not merely interdisciplinary but problem-oriented in a way that transcends disciplines; and to imbue students with an understanding of the place of research in the entire process of innovation. □

The Boundary Dynamic



The Boundary Dynamic

The performance of a polymeric adhesive depends on the properties and composition of its surface. Now a scientist at the General Motors Research Laboratories has developed and validated a theory that describes the coupled effects of diffusion and chemical reaction on the changing surfaces not only of adhesives, but of chemically reacting surfactant systems in general.

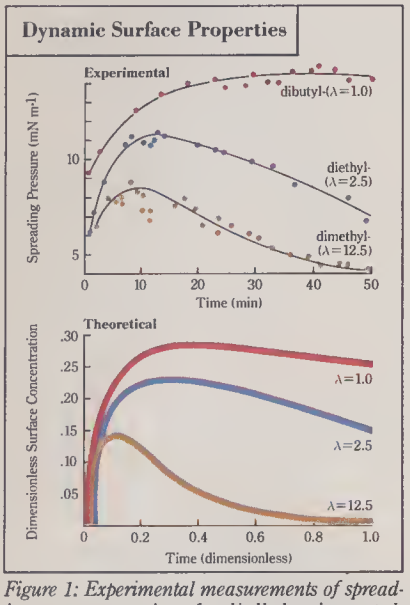


Figure 1: Experimental measurements of spreading pressure v. time for dialkylaminopropylamines with various Damköhler numbers (λ), and corresponding theoretical calculations of surface concentrations.

THE USE OF adhesives in the production of an automobile promises to make both the product and the process more efficient. Both weight and operations can be reduced. In practice, however, steel and other metallic surfaces are often contaminated by process lubricants. A durable bond depends on the ability of an adhesive to displace contaminants and to wet the substrate.

Assuring intimate contact between adhesive and substrate requires detailed knowledge of adhesive surface tension, since it is this property that controls displacement of contaminants and wetting. Up to now the surface tension of an adhesive has typically been assumed constant. In reality, though, surface-active components in the adhesive collect preferentially at the interface and also react, so that the surface composition varies with time, giving rise to dynamic surface tension. Variations can be large enough to significantly affect adhesive performance.

The understanding of time-dependent surface tension has been advanced by the work of Dr. Robert Foister, a scientist at the General Motors Research Laboratories. Investigation of dynamic surface properties of thermosetting adhesives led him to develop a general theory of adsorption kinetics in binary, chemically reacting surfactant systems. The significance of this theory is that it includes the coupled effects of surfactant diffusion and chemical reaction, making it possible for the first time to describe quantitatively the changing surfaces of such systems.

In a typical adhesive that polymerizes, or "cures," by chemical reaction (Figure 2), a surface-active curing agent (Solute 1) reacts with the host resin to form a second surface-active species (Solute 2) that is also reactive. Both solutes migrate to the surface, lowering the surface tension. Diffusion to the surface is driven by a potential energy gradient between the surface and the bulk, with the solute molecules experiencing a lower energy at the surface.

Dr. Foister derived appropriate transport equations to describe diffusion and chemical reaction in the bulk, in a subsurface region, and at the surface itself. The transport equations can be solved analytically if the chemical rate equations are assumed to be first order in the concentrations of reacting species, and if the subsurface and surface concentrations can be related to one another by a linear adsorption isotherm. For more complicated isotherms, a set of coupled, non-linear integral equations is generated.

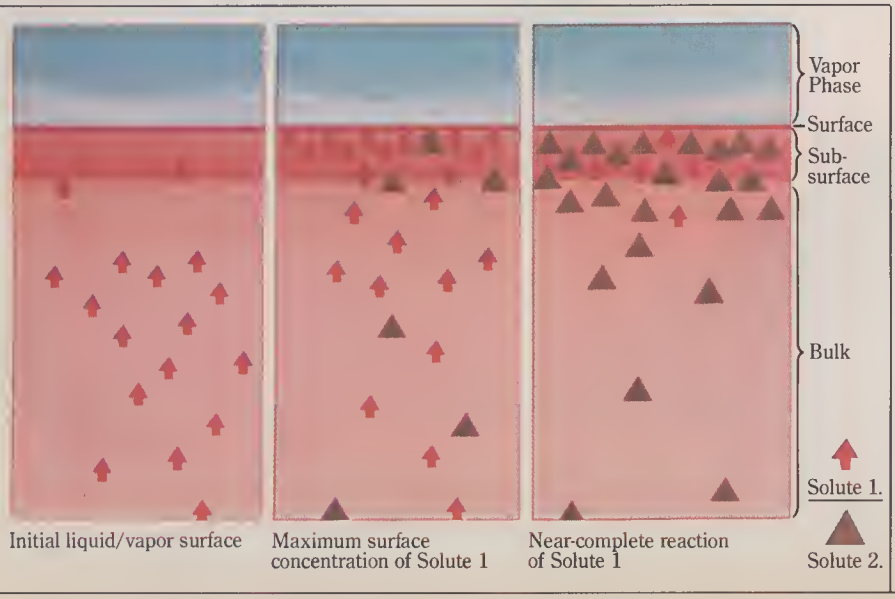


Figure 2: Evolution of an adhesive surface: Surface-active Solute 1 (red) reacts with host resin (pink tone) to form surface active Solute 2 (brown).

These must be solved numerically.

Analytical solution for the special case of the linear isotherm indicated that the change with time in surface concentration (and consequently in surface tension) is composed of two terms: first the diffusive flux of Solute 1 into the subsurface from the bulk, and second the depletion of this solute due to chemical reaction. Hence, the surface concentration of Solute 1 exhibits a maximum with time (Figure 2). This maximum in surface concentration corresponds to a minimum in surface tension.

MODIFYING the transport equations to include binary adsorption isotherms allowed for consideration of competitive adsorption of the two reacting and diffusing solutes. By solving these equations numerically and conducting dimensional analysis, Dr. Foister identified various dimensionless parameters as predictors of system behavior. The most important of these parameters was a dimensionless number (λ), of the Damköhler type, involving terms representative of reaction, diffusion, and adsorption.

$$\lambda = \frac{k\,(\Gamma_m\, a)^2}{4D}$$

Here k is the reaction rate constant of Solute 1, D its diffusivity, Γ_m its "surface capacity" (the maximum number of molecules absorbed per unit surface area), and a its "surface affinity" (a measure of its energy of adsorption). For an adhesive, lowering λ by reducing k (the reactivity of the curing agent), for example, would prolong the time to maximum, and would increase the value of the surface concentration at the maximum (see Figure 1, Theoretical). As a practical consequence, this would improve wetting by minimizing the surface tension.

In experiments using a series of dialkylaminopropylamine curing agents (dimethyl-, diethyl-, and dibutyl-) in a host epoxy resin matrix, good agreement has been demonstrated between theoretical predictions for surface concentration and the measured dynamic spreading pressure, which is the change in adhesive system surface tension due to the curing agent (Figure 1, Experimental).

"I expect," says Dr. Foister, "that the physical insights gained from this analysis can be applied to other reactive surfactant systems by using specifically tailored isotherms and chemical reaction schemes. Predicting surface behavior can certainly help us design better adhesives for specific applications, but it is also pertinent to the performance of anti-oxidants and anti-ozonants in synthetic rubber, for example. And applied to interfaces in biological systems, a suitably modified theory may prove valuable in understanding the phenomenon of enzyme activity."

THE MAN BEHIND THE WORK

Dr. Foister is a Staff Research Scientist in the Polymers Department at the General Motors Research Laboratories.

Dr. Foister received his undergraduate degree from Guilford College, and holds a Ph.D. in Physical Chemistry from the University of North Carolina at Chapel Hill. His thesis dealt with the role of liquid inertia in the intrinsic viscosities of rod-like polymers.

He did post-doctoral work in Canada as a Fellow at McGill University in Montreal, and in the Applied Chemistry Division of the Pulp and Paper Research Institute of Canada, working on the microrheology of colloidal dispersions.

Dr. Foister joined General Motors in 1980. He is the leader of the Structural Adhesives Group in the GMR Polymers Department. His current research interests center on surface chemistry and adhesion.

BUSINESS STRATEGIES

AFG Industries:
SPECIALTY GLASS GIVES A CLEAR VIEW TO PROFITS

AFG Industries, an aggressive young glass company based in Kingsport, Tenn., is proof that computer chips aren't the only products to benefit from advances in using silicon. AFG's willingness to develop new technology helped it grab the profitable specialty-glass market niche, with products such as energy-absorbing colored glass, mirror glass, tempered glass, and appliance glass, says Dorothy M. Fels, director of research for the investment firm Parker/Hunter (Pittsburgh).

"The competition thought nobody would move into the market so quickly," says Fels. By developing a coated, high-efficiency insulated glass, AFG has taken advantage of a thriving market in home and office remodeling. And by producing glass that can transmit an extremely high percentage of sunlight to solar collectors and photovoltaic cells, it has carved a leading position in these growth fields as well. The company has also enlisted some high-powered help; it currently has joint projects with Atlantic Richfield Co. to develop photovoltaic cells and McDonnell Douglas to increase the efficiency of solar collectors.

Since 1978, when it acquired its current identity with the merger of two previously floundering glass companies, AFG has posted 55% compound earnings growth on sales that have increased an average of 23% annually. The company is now the nation's fifth largest flat glass manufacturer, in an industry dominated by PPG (formerly Pittsburgh Plate Glass) and Libby-Owens-Ford. And with fiscal 1984 sales of $281 million, the company is now number one in specialty glass.

Although the company's heavy R&D spending will cut into profits this year, says Claire Armentrout, an analyst for J. C. Bradford & Co. (Nashville, Tenn.), she believes the competitive edge it gains will pay off in the long run. For example, she rates AFG's "low-E glass" (which is coated with a substance that admits the sun's rays and simultaneously minimizes heat loss) "superior to any other company's." While a similar product from PPG lets 72% of sunlight through, AFG's glass lets 84% of sunlight enter, and it is priced lower, says Armentrout.

AFG's Ron Tiller looks over glass-cutting machinery, which automatically scores glass ribbon to predetermined lengths.

Analysts credit much of AFG's success to the farsightedness of its chairman, R. D. Hubbard, a former school teacher and auto windshield salesman. In 1976, he took the helm of Fourco Glass (Clarksburg, W.V.)—which later became AFG—a company that was $32 million in debt and losing $1 million more a month. Hubbard shut down plants that made glass with an obsolete and expensive sheet method, slashed the payroll, and brought in modern glass-making expertise. In six months, the company broke even and 10 months later earned a profit of $6.8 million. Hubbard and his partners then bought a majority interest in ASG Industries, the U.S. operation of France's Compagnie de Saint-Gobain, and merged the two companies in 1978. Since then, AFG has acquired several small glass distributors and makers of specialty products such as mirrors and aquariums.

In addition to pursuing specialty markets, the company's newest strategy is to sell entire glass-making plants based on its own version of the conventional "float" process called the "mini-float." In contrast to the drawn process (in which glass is pulled from a vat like taffy and flattened by rollers) or the sheet process (in which it is poured on a flat surface, cooled, and ground smooth), the float process (in which a ribbon of melted glass is injected onto a bed of molten tin) is more efficient and results in fewer flaws. But conventional 500-ton-per-day plants are prohibitively expensive to build. AFG proposes to build plants that are smaller (250 tons per day) as well as able to run at higher temperatures, allowing manufacturers to reduce lead content and produce clearer glass.

"We developed the mini-float for people around the world who need a small glass plant," says Ron Tiller, AFG's vice-president of planning and corporate development. Even in the U.S., it is doubtful that another large-scale float plant will be built, he argues, because "glass will be produced in the area where it is used." AFG is building its own mini-float plant in California to serve the region west of the Rockies, but hasn't yet sold the technology to an outside customer, despite negotiations with 31 countries. But the company remains optimistic. "If the mini-float system takes off," says analyst Fels, "it could open up a whole new market."

—Robert Snowdon Jones

Hypres:
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HOUSTON WORKS FOR BUSINESS

based on conventional solid-state technology are already approaching inherent speed limits imposed by such barriers as the time it takes a transistor to switch between the "off" state and the "on" state. Yet two-year-old Hypres (Elmsford, N.Y.) is developing a superconducting switch, based on the Josephson junction, which it believes can increase switching speeds by a factor of 100.

The devices consist of an extremely thin layer of insulation separating two strips of superconducting metal that, when chilled to temperatures near absolute zero (0° Kelvin, or −273° C), offer no resistance to an electrical current. By varying the amount of current, one can make the junction act as a switch; at certain levels, current flows through the insulation, while at other levels it does not.

IBM, which pioneered much of the work with Josephson junctions, has produced devices that can switch in 1.5 picoseconds (trillionths of a second)—far faster than the 11-picosecond switching time researchers have managed to squeeze out of today's state-of-the-art semiconductor devices, gallium arsenide transistors. Hypres predicts that technical advances will make the switching time for a Josephson junction fall to a mere 0.1 picosecond within four years. As an extra bonus, superconducting junctions don't heat up, because they offer no resistance to current. Therefore they can be packed as densely as manufacturing processes allow, making operation even faster.

Given the advantages of the Josephson junction, why has it taken 20 years since its discovery for the first commercial components to roll off the assembly line? Because superconducting devices also pose tremendous difficulties—so severe that IBM, once the world leader in Josephson junction research, dropped its $20-million-a-year program in 1983, claiming that breakthroughs in computer chip technology were more likely to come from other areas.

That's where Hypres came in. IBM researcher Sadeg Faris obtained venture capital backing, licensed IBM's patents pertaining to Josephson junctions, and founded the new company in May 1983. Hypres thinks it has solved

A technician monitors thin-film deposition equipment that Hypres uses to fabricate superconducting chips.

one of the biggest problems that plagued IBM—keeping the devices stable throughout the demanding manufacturing process—by using niobium instead of lead as the superconducting material. Niobium is better able to withstand repeated swings between cryogenic temperatures and room temperature. And while IBM was attempting to integrate the thousands of devices per chip required for computer components, Hypres is content—at least for now—with 20 or so devices per chip.

The company's first products will be a line of digital test and measurement equipment that it claims will operate five times faster and far more sensitively than competitive semiconductor-based products. The Hypres equipment will cost more, says vice-president of sales and marketing Ravi Ghai, but should also give a better price/performance ratio. Cooling systems (niobium nitride becomes superconducting at 16.2° K) will make the first units quite bulky, but the company expects to have transportable versions out within three years. Among target applications are gallium arsenide chip production, optoelectronic component and equipment production, and communications equipment development.

The Department of Defense is also showing serious interest in supercooled components, which could boost the performance of communications receivers, analog processors, and high-resolution imaging equipment. The Navy has awarded Hypres a $500,000 contract to develop a 1000-device Josephson junction chip, and other defense contracts are under discussion, the company reports. Josephson junction technology is particularly attractive to developers of satellite-based systems for the Strategic Defense Initiative ("Star Wars"), because temperatures at orbital heights drop to as low as 4° K, making refrigeration unnecessary. However, the DOD market for Hypres's technology will remain smaller than the test and measurement market for some time, contends Henry Kressel, managing director of E. M. Warburg Pincus and Co. (New York), the venture capital firm that is the leading contributor to Hypres's $7.5 million in backing.

Although Hypres is the only U.S. company now working on Josephson junction chips, it has formidable competition from such Japanese companies as Hitachi, Fujitsu, and Nippon Telegraph & Telephone. Japanese researchers have already produced working Josephson junction–based read-only memory chips that can store 2K bits of information, integrating thousands of junctions instead of tens of devices as in Hypres's current chips. Although such a feat puts Hypres distinctly in second place, Ghai remains optimistic. "We'll catch up through small-company agility," he says.

—David H. Freedman

Biosonics:
FOLLOWING FISH UPSTREAM WITH SONAR

Watching salmon fight their way up wild, swollen rivers may seem like an odd task for high tech executives. But not for officials of BioSonics (Seattle), a manufacturing and consulting company that specializes in

fisheries research. Founded in 1978 by University of Washington electrical engineers Bill Acker and Alan Wirtz, BioSonics employs 40 to 75 people—the numbers rise when the salmon are running—and expects to take in $4 million this year performing studies and selling such equipment as a sonar system for monitoring fish in turbulent rivers.

BioSonics has developed sonar systems that work in fresh water environments such as fast-flowing rivers, where reverberations from the foaming surfaces and the shallow, rocky bottoms stumped researchers in the past. By developing higher-frequency transducers for better resolution and devising sampling techniques that make accurate measurements possible in constricted areas, the company has created a new class of hydroacoustic tools. Among them is a Doppler processor for counting fish like salmon and steelhead trout as they migrate up rivers to spawn. The processor is based on the phenomenon that causes echoes from fish swimming upstream to have a different frequency from echoes bouncing off the stationary river bottom. Another device is a dual-beam sonar system for measuring the size of fish. Whereas a sonar beam—like a flashlight beam—is most intense at its center, making the strength of an echo vary as a fish passes through it, the dual-beam system compares the echoes from two overlapping beams to come up with accurate dimensions.

These tools have arrived at just the right time, as government and private-sector scientists are implementing a spate of new efforts to save dwindling salmon runs and increase fish harvests (see "Engineered hormones make salmon grow faster," p. 11). On the Columbia River, for instance, a string of nine dams collectively kill as many as 90% of the young fish from some salmon runs before they reach the sea. For scientists and dam operators trying to improve the survival rate, BioSonics has filled "a real void," says Don Weitkamp, a biologist with Parametrix (Bellevue, Wash.), a consulting firm in fisheries and environmental research.

The new sonar techniques allow biologists to "see" how salmon approach dams, enter currents flowing into turbines or spillways, and even swim through cavernous underwater galleries within the dams. The information can help the Army Corps of Engineers, the Bureau of Reclamation, and private dam-operating utilities build new passages for fish and regulate water flow to help salmon swim past the dams. Much of this work is part of a $750 million, 20-year program funded by electricity ratepayers in the region, who have indicated in polls that they are glad to pay an extra percent to restore the Columbia's once huge populations of salmon and steelhead.

JOHN STAMETS

BioSonics president Bill Acker poses with some of the company's sonar-based fisheries research instruments. In front of him is a dual-beam transducer used to determine fish size; behind is an array of receiving equipment.

By tackling this difficult market, BioSonics surprised competing sonar makers who thought the field was too small to pay back extensive R&D costs. Most sonar makers concentrate on military instrumentation or commercial fish-finders for oceangoing vessels, although a few companies, such as Norway's Simrad, make equipment for large-scale oceanographic and fisheries studies. But the recent surge of environmental and conservation laws has greatly spurred demand for smaller-scale environmental studies. Moreover, BioSonics' Acker believes the company's combined manufacturing and consulting activities give it a strategic edge. The dual-beam sonar system, for example, grew out of projects for clients who wanted to estimate the biomass of fish stocks and determine the percentages of large and small fish.

BioSonics is also pursuing business abroad, as governments worldwide turn to hydroacoustic surveys to help them find new fish stocks and avoid overfishing. With funding from international aid organizations, BioSonics was hired three years ago to set up a fish-stock assessment program for Senegal and, shortly thereafter, to calibrate equipment used by fisheries managers in Ecuador, Chile, and Peru. The U.S. National Marine Fisheries Service uses BioSonics equipment in the North Pacific to help estimate the yearly census of massive whiting and pollock stocks—data needed to set quotas for foreign and domestic fleets.

However, fisheries studies have only recently begun utilizing high tech instrumentation, and BioSonics hopes to keep stretching the technology's limits. For instance, it plans to introduce a computerized optical-pattern-recognition system to identify fish by patterns in their scales—a tool that might help resolve international disputes over who is catching whose fish on the high seas.—***Brad Warren***

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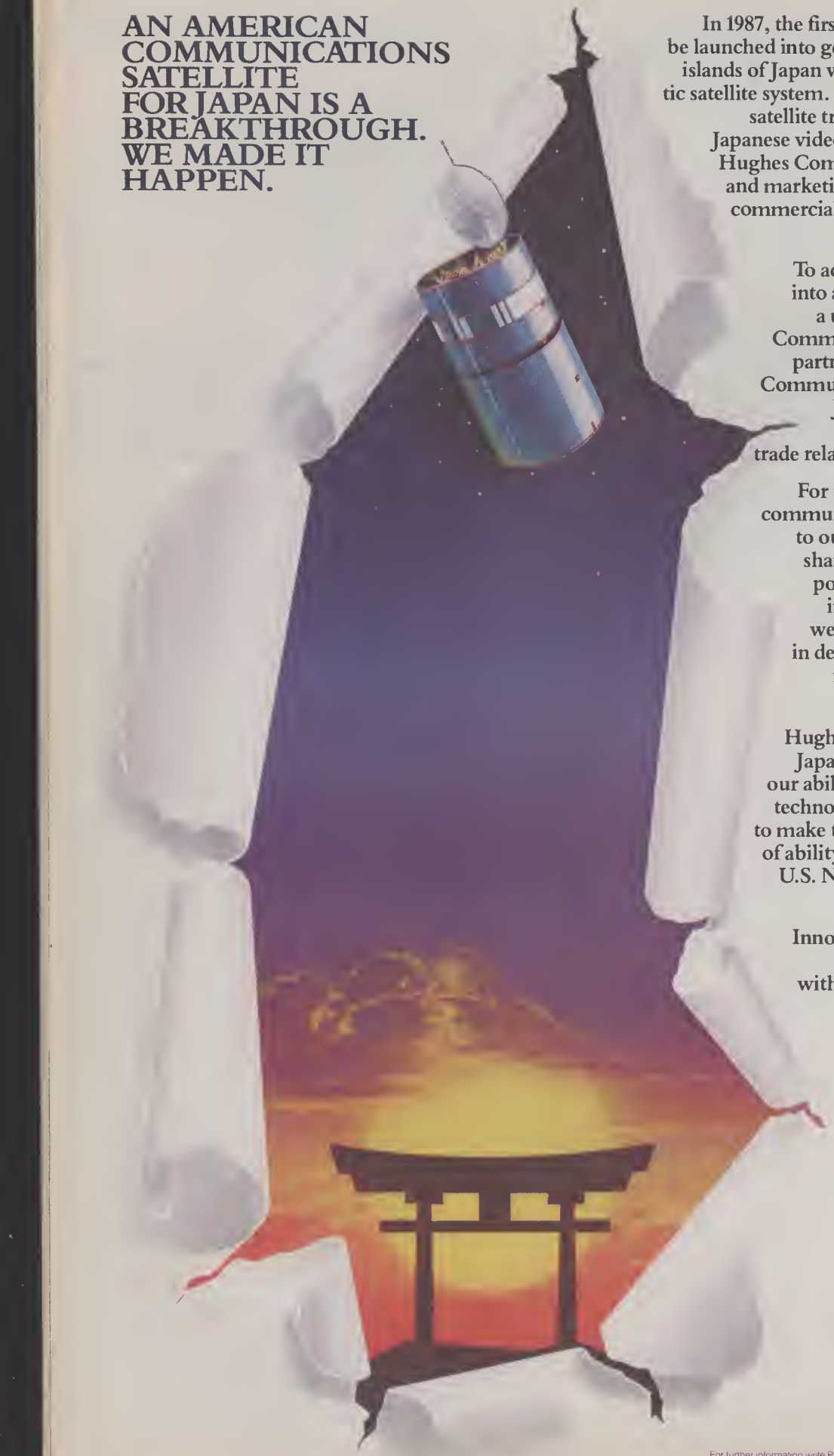

In 1987, the first of two Hughes-built satellites will be launched into geosynchronous orbit, supplying the islands of Japan with a high-quality, low-cost domestic satellite system. For the first time, 64 high-powered satellite transponders will be available for the Japanese video and telecommunications industry. Hughes Communications is providing technical and marketing know-how to help Japan build a commercial satellite communications industry virtually from scratch.

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MICROS AT WORK

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The microcomputer, originally little more than a sophisticated toy, is rapidly becoming a valuable tool for business, research, and education. Whether in the office, the factory, the laboratory, the school, or "the field," the micro is providing an inexpensive route to enhanced productivity. And despite the past year's slowdown, it's likely that we ain't seen nothin' yet.

The articles that follow examine reasons for the micro's increasing utility, as well as factors that still constrain it. A Business Outlook analyzes the state of the microcomputer industry—how it might rise from its current plateau to further realize its potential, still largely untapped. A Technology Overview describes recent advances in hardware and software that increase the micro's power, range, and accessibility. Finally, an Applications section presents a virtual "Whole Earth Catalogue" of case studies to show the wide spectrum of time- and money-saving uses that micros are already serving.

TOMORROW IS ANOTHER DAY

Sobered by decelerating growth, the microcomputer industry hopes to court customers with new and better software

BY SARAH GLAZER

After several years of phenomenal growth, the microcomputer industry is mired in its first slump. Former stars are turning in quarterly reports filled with red ink—Apple reported a $17 million loss in its quarter ending in June, and Commodore announced an expected $80 million loss for the same period—and even IBM has revised its earnings forecasts downward this year because PC sales have been slower than anticipated. Whereas the number of business micros shipped in 1984 increased 55% over the previous year's total, 1985's increase will be a much flatter 15%, predicts International Data Corp. (IDC) in Framingham, Mass. And home computer sales, which IDC estimates increased only 6% in 1984 over the previous year's total, will drop 25% in 1985.

For manufacturers, this is a time of rethinking, retrenching, and—in some cases—just trying to stay afloat. For many customers, it's a wait-and-see period for reassessing needs, evaluating new technology, and finding out which vendors and computers will have staying power. And for a vast, untapped potential market, it's simply a question of waiting for vendors to adapt products to its needs.

"We're on a plateau, where people are digesting the hardware and software they've bought," says Danielle Barr, vice-president of corporate systems at the Boston-based Bank of New England. "We've educated 800 people in the last three years to use PCs, but we've saturated that professional level." To convince more potential users at the bank to work with PCs, she believes, software will have to address a variety of functions as effectively as it deals with number crunching and word processing. For instance, to make PCs effective tools for managers (the next group Barr is targeting at the bank), it might well be necessary to obtain software designed specifically for managerial tasks.

"Business microcomputers have penetrated less than 20% of their potential market," contends Ben Rosen, chairman of Compaq Computer (Houston) and principal of venture capital firm Sevin & Rosen Management (New York), because the scope of today's PC applications is still very limited. "To go from 20% to 100%," he says, "we need new software."

Some observers believe that before a cross section of the public will be willing to use micros, very specialized software will have to be developed for almost every industry and occupation. Others maintain that, instead, the next generation of general-purpose programs will be so easy to use that anyone can customize them for individual jobs, thus making specialized programs unnecessary. In any case, most of today's industry- and occupation-specific programs for PCs are scaled-down versions of software developed for big computers used in fields such as electrical engineering, law, and banking. Creating such programs is quick and relatively inexpensive, but their potential market is already teeming with computers.

Ironically, smaller businesses, for which micros are the ideal (and often the only affordable) computer solution, are left in the cold. Micros could be invaluable tools for most restaurants, says Harvey Fitterman, owner of American Lunch, an Atlanta cafeteria, but few proprietors can underwrite the development of specialized software. Fitterman, who was lucky enough to have an aunt willing and able to program his Commodore 64, says the PC allows him to calculate such variables as profit margins for individual menu items and to monitor the effect of changes in the prices of ingredients. "Otherwise, I might not realize that I was selling a dish for $2 that it cost me $3 to make," he says.

But while the majority of restaurateurs and other small-business owners may have to wait for micros to reach their line of work, potential users in other fields are voluntarily deferring purchases, dazzled by the rapid pace of technological change. In computer-aided engineering, for example, leading vendors of powerful workstations have started to sell scaled-down versions of their software for PCs (usually on the new high-powered models like the IBM PC/AT). In some cases, PC-based systems are almost as versatile as their high-end siblings, especially when add-on circuit boards give the micros a boost in horsepower. "A PC-

"To go from 20% to 100% penetration of the PC's potential market," says Compaq's Ben Rosen, "we need new software."

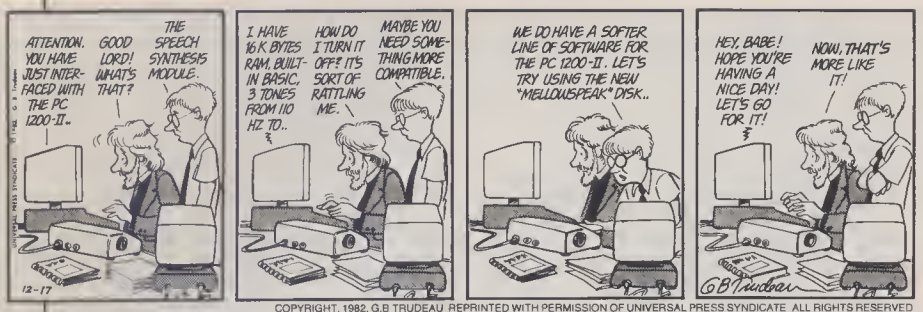
based system for computer-aided design may give 80% of the functionality of an expensive system," says William Hambrecht, president and CEO of the Hambrecht & Quist Group, an investment banking firm in San Francisco. "But people want to wait" before buying, he believes, both to evaluate this technology and to determine which features they need.

Changing technology in business micros is making commercial users defer purchases as well. "Some of our corporate accounts are waiting for local-area network developments," says Bill Van Dusen, a national sales manager for Tandy (Fort Worth, Tex.), or are waiting to see if—and under what conditions—software vendors will offer site licenses (discounts) for volume users of application packages.

The presence, or promise, of new micro technology from IBM can of course have a profound effect on the market. Users in all kinds of professions are anxiously awaiting the debut of the company's second-generation PC workhorse, the PC2, although its expected announcement date has slipped from April 1985 to August and, now, to some time in 1986. Rumors are that the machine (like the PC/AT) will be based on Intel's powerful 80286 microprocessor—which will make IBM's original PC seem anemic in comparison. Since no one knows to what degree software for the first- and second-generation machines will be interchangeable, some users are opting to wait rather than buy what may all too soon be outmoded technology.

Finally, because all these developments are taking place against the backdrop of an industrywide slowdown, the pressure to defer purchases is even stronger as vendors compete by dropping prices lower and lower.

Stepped-up competition has already



contributed to a number of casualties, not only among the smaller contenders (Franklin Computer, Osborne, and Victor Technologies have declared bankruptcy) but also among the mighty (IBM discontinued the PC-jr., and DEC has pulled the Rainbow out of the retail market). By most predictions, the carnage is far from over. "The market and the channels of distribution can't support the number of companies competing," says Compaq's Rosen. "There are more companies trying to sell than there is shelf space."

But while such pressure may squeeze some companies out of the market, it can also help consolidate the strength of others; customers are becoming increasingly wary of buying one of tomorrow's computer "orphans." Future Computing, a Dallas market research firm, estimates that IBM has increased its market share from 30% in 1983 to 40% in 1984, Compaq from 2.6% to 4.3%, and Zenith from 2.5% to 3.2%. And the silver lining of this shakeout for the general public—apart from the lowest prices ever for computers, peripherals, and components—may be the boost it has given to industrywide de facto standards; weeding out the field reduces the confusion.

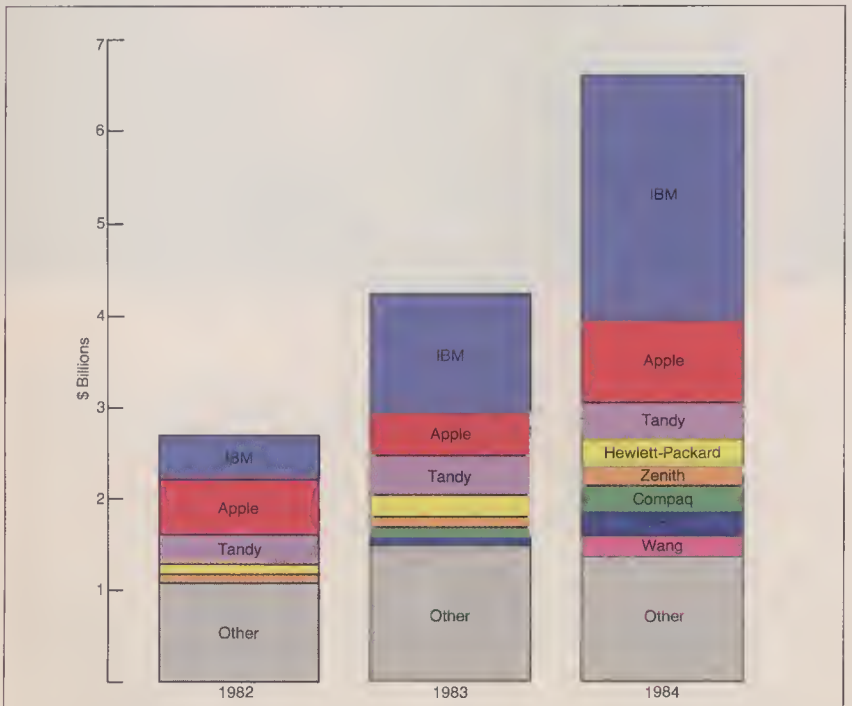
The PC makers that have remained viable are trying to differentiate themselves from their competitors, either by picking specific market niches or by devising innovative marketing strategies. For example, Compaq owes much of its success this year to its focus on high-powered systems. The company began selling PC/AT clones months before IBM was able to make volume shipments of the PC/AT itself, an engineering and manufacturing feat that helped Compaq grab the lion's share of high-end system sales last spring.

Zenith (Glenview, Ill.) owes much of its increased market share to sales of PCs customized to the U.S. government's "Tempest" program, which outlines data security and ruggedness requirements for computer equipment. A year ago, Zenith was awarded a $100 million contract to supply such PCs to the Air Force, Navy, and Marine Corps. The company has decided to continue "optimizing products for specific applications," says Andrew Czernek, Zenith's director of marketing, and may develop PCs for other security-sensitive niches as well as pursuing more generalized market segments, such as universities.

Tandy—which has lost market share since 1983 (according to Future Computing)—is trying to strengthen its position by focusing on its unusual service capability rather than on particular product features. Having abandoned earlier attempts to base its product line around its own software standards, Tandy's best-selling models today are IBM look-alikes. Where the company stands out is in its nationwide chain of Radio Shack stores that offer "local service, repair, and training facilities to 95% of the populated regions of the country," claims sales manager Van Dusen. Because PC sales at its retail outlets have dropped significantly, he says, Tandy has targeted bigger companies, especially those with far-flung branches, by beefing up its direct sales force.

Other manufacturers—aside from IBM, which is in a class by itself—are also pursuing their own niches or playing up individual strong points. For instance, Epson America (Torrance, Cal.) makes a special low-priced model of its IBM-compatible PC that is geared to resellers, who will market the machines with their own industry-specific software. Data General (Westboro, Mass.) is targeting "traveling businesspeople," such as sales forces and service engineers, with its briefcase-size portable PC.

Not everyone is specializing; perhaps the most glaring exception is Apple (Cupertino, Cal.), which—despite its dominance of the home and educational markets—is vigorously pursuing general business customers with the Macintosh. But specialization is the trend, says Compaq's Rosen, and it may simply be a sign that the microcomputer industry has passed through its infancy and is maturing—that inevitable cycles are squeezing most manufacturers into a more focused approach. "Business micros are becoming a $10 billion industry now," he says. "You can't grow forever at the same pace." □



The market for business micros has grown dramatically, but IBM's share has grown even faster; Future Computing predicts that it may well top 50% in 1985.

Source: Future Computing

IMPROVING THE TOOLS

New developments in hardware and software are making the micro stronger, more versatile, and easier to use

HUMAN INTERFACE

The Macintosh look catches on

Perhaps the biggest recent advance in the PC user interface is that computer maufacturers and software companies have finally realized it exists. Instead of leaving the communication between user and computer to chance, whim, and a keyboard, vendors have begun designing combinations of hardware and software that are easy to learn and simple to use. The pioneer in this area was Xerox's Palo Alto Research Center, but the popularizer was Apple Computer with its Lisa and Macintosh microcomputers.

"Manufacturers of products for other computers have been looking at the Mac with envy," says Paul Cubbage, a senior industry analyst with Dataquest (San Jose). In fact, some companies are doing more than just look. Recently introduced products that mimic the Macintosh's screen presentation include Digital Research's GEM software for IBM PCs and clones, Atari's and Commodore's new graphics-oriented microcomputers, AT&T's multiuser Unix-based business computer, and Hewlett-Packard's Unix-based portable engineering workstation. Even IBM has incorporated the Macintosh concepts in its Topview interface program for the PC, PC/XT, and PC/AT.

What has emerged as a standard is a user interface that features a mouse pointing device for cursor positioning, pull-down or pop-up screen menus from which to select programs and do jobs such as copying files, and multiple windows that simultaneously display different programs. Building on this foundation, computer systems have added high-resolution graphics and pictographic representations called icons for important objects and commands. Ideally, the interface remains constant from application to application, presenting the user with a similar screen format whether the computer is running a spreadsheet or a game package.

But although the Mac-like interfaces are superficially similar, their internal workings are often radically different. This can present some difficult technical problems for companies that try to implement more than one type. Moving a program from a Macintosh to a Hewlett-Packard Integral workstation, for instance, or from an IBM PC running GEM to a Commodore Amiga, is an enormous job. Indeed, writing or modifying software to run under even a single interface can be arduous. Initial sales of the Macintosh were hurt because it was almost a year before much software became available—a situation that software companies blame partly on the complexities of writing programs that exploit the features of the interface.

Some interfaces, including Topview, Microsoft's Windows, and Quarterdeck Systems' Desq, attempt to avoid this pitfall by running much existing software without change. But this can be a daunting task. Application software programmers often boost performance through nonstandard programming techniques, making it tough for the interface vendors to ensure that most of the popular preexisting programs will work in conjunction with their interface software. Even when the applications do run, they can rarely take full advantage of the interface's features.

Mac-like interfaces are growing in popularity, but are by no means universally appreciated. Some users object to the amount of processing power needed to support them, while others dislike certain features, particularly the mouse pointing device used to move the screen cursor and to initiate certain processes. Users must take one hand off the keyboard to operate the mouse, and they need a square foot or so of open desk space to accommodate it.

Nevertheless, nothing else seems to offer the combination of low cost (typically $100–$200), ruggedness, simplicity, and precision. Mice routinely work in increments of a hundredth of an inch (a unit called a "mickey" in the mouse business). A graphics tablet with an electronic pen can have a higher resolution, but only at a higher

cost. A touch screen, such as that of the Hewlett-Packard 150 has an array of LEDs and photodiodes set in the bevel around the screen; when a finger breaks a horizontal and a vertical LED beam, its *x-y* coordinates can be determined. But although the HP150 is sturdier, simpler, and arguably cheaper than a mouse (cost comparisons are difficult, since the touch screen is built-in), it doesn't have nearly the same resolution.

Despite its advantages, the mouse is far from the last word in human/computer communications. Many look forward to a day when personal computers will talk and respond to spoken commands, and there is much enthusiasm about the potential of artifical intelligence (AI), which could let computers interpret ordinary sentences.

Voice recognition and speech synthesis are just beginning to come into their own, following years of false starts. The technologies are now being used in applications where their current costs and limitations can be justified, but they won't be generally available on personal computers for some time. A variety of technologies are employed to recognize spoken words, but all use some method of matching phonetic sounds with stored patterns of words in the system vocabulary. Although several companies offer such systems—notably Texas Instruments, Votan, and Kurzweil Applied Intelligence—most PC manufacturers believe these systems still require too much computing power to be widely useful. Also, most "speaker-dependent" systems can understand only a few words, and all must be "trained" to understand each speaker. Voice quality from speech synthesizers, while improving, remains generally poor.

In the area of AI-based user interfaces, several database programs now support query languages with at least some ability to accept questions typed in English. The most familiar of these is the Clout natural-language interface from Microrim (Bellevue, Wash.), which works in conjunction with the company's R:base database management systems; other natural-language systems are also designed to query specific databases. General-purpose natural-language interfaces would require considerably more processing power and memory, and while some companies are reportedly working on developing such products—they would be extensions to existing operating systems and user interfaces—none has yet been announced.

The purpose of all this interface activity, of course, is to make computers easier to use and more accessible to nonspecialists. If this quest proves successful, interfaces could broaden the appeal of personal computers and help to revive the market. "I think we've sold all the computers we can expect to sell to people who are willing to put up with gibberish," says John Peers, founder and director of Novix (Santa Clara, Cal.), a microprocessor manufacturer. The ultimate goal, he says, is to design an interface so that even an unskilled user can sit down at a computer, operate it with ease, and get good results. □ ***—Rick Cook***

GRAPHICS

Inching toward standardization

Microcomputers have always had some form of graphics capability. But it has usually been limited to rough, block-type images whose diagonal lines have that "stair-step" look. Reflecting this hardware limitation—which is imposed by memory and display costs—major business software has typically been text-oriented, displaying and printing alphanumeric information as if the PCs were little more than electronic typewriters. But in the past year or two, the sorry state of microcomputer graphics has improved substantially. In fact, the IBM Personal Computer (in its common monochrome screen form) is probably the last important text-based microcomputer.

New microcomputers, by contrast, work permanently in graphics mode, even for text, and can display multiple typefaces and type styles (roman, italic, boldface) directly on screen and print them on paper. The graphics orientation also gives the software developer freedom to use icons and other devices to improve the user interface. The Macintosh from Apple (Cupertino, Cal.) became the first successful graphics-based microcomputer, and the recently announced ST from Atari (Sunnyvale, Cal.) and Amiga from Commodore (West Chester, Pa.) are now following in its footsteps.

Full-time graphics has been slow to arrive in micros because it calls for considerably more sophisticated hardware and software than do the text-only systems. A text-based system can put a character on screen merely by sending a short code to the memory location where the character pattern—made up of discrete points, or pixels—is stored; the video driver simply retrieves the fixed pixel pattern and displays it in a standard-size rectangular area on the screen. With a graphics-based micro, the software must determine the typeface, size, and style, and then calculate each pixel in the desired character. Only with the advent of powerful new microprocessors and inexpensive memory chips has the computing- and storage-intensive graphics approach become feasible on small computers.

Virtually all microcomputers use an industry-standard code (ASCII) to manipulate text information; graphics, on the other hand, is anything but standardized. Some computer models use consistent formats for describing images in all their application software, so that programs from different publishers can exchange pictures and other data. A graphics standard uses elemental shapes called graphics primitives to build up images by specifying lines or curves of a particular thickness, size, orientation, and position. Using the primitives, each display device—from CRT to typesetter—can render the image at its own best resolution. For instance, an ordinary, low-resolution CRT cannot show a circle clearly, but a laser printer with resolution of 300 dots per inch can take the same graphics primitive and draw a smooth image.

The Macintosh, Atari ST, and Amiga each incorporate a consistent graphics format for their own software, but the three formats are incompatible. The ubiquitous IBM PC doesn't provide a graphics format at all—an omission that has severely inhibited graphics software development for that machine. In the absence of a standard for the IBM PC, Lotus's 1-2-3 program has managed to spawn many products that use its graphics format, but this format is limited to rudimentary business charts. At this point, quality graphics for the IBM PC and PC/XT is probably a lost cause; they lack sufficient computing horsepower and are already approaching the end of their life cycles.

For the IBM PC/AT class of micros, however, the industry is slowly moving toward a standard called the virtual device interface. VDI has been codi-

fied by the American National Standards Institute (ANSI) and is at the heart of the graphics standards incorporated in such new software products as GEM from Digital Research (Pacific Grove, Cal.), Windows from Microsoft (Bellevue, Wash.), and the graphics development tools from Graphic Software Systems (Wilsonville, Ore.). Despite ANSI's attempt at standardization, however, these products use three variants of VDI that are not strictly compatible. (GEM and Windows use the graphics format not only to direct program output but also to construct a Macintosh-like user interface, giving IBM's machines a screen presentation that incorporates icons and supports a mouse input device.)

Aside from being prone to incompatible variations, the VDI standard has other shortcomings. It fails to provide for a major class of images: arbitrary raster graphics. These line-by-line images—such as those produced by a television camera—cannot be described easily in elemental shapes. VDI also provides for graphics primitives only at a simple, elementary level. If a program draws a four-sided box, for example, VDI will define the object as four separate lines, having no way to specify that the four lines constitute a single entity that should be operated on as a unit by software. Finally, VDI does not have a sufficiently rich set of specifications for typography; among other things, this means it cannot describe a page layout to typographic standards.

Because of these limitations, no single graphics standard seems universally suitable. Extensions and conversions into other standards will always be necessary for more sophisticated applications. To drive laser printers and typesetters, for example, a general-purpose graphics format might be upgraded into a high-quality format called a page description standard. This standard could work in conjunction with page makeup software to fine-tune text and graphics for high-resolution output devices. Two page description standards are currently competing for industry support. One, PostScript from Adobe (Palo Alto, Cal.), has been adopted by Apple for the Macintosh and by several independent software publishers for IBM microcomputers. The other, the Interpress standard from Xerox (Palo Alto), has thus far received support mainly from the minicomputer industry, although Xerox wants to move it into the personal computer realm.

Once the graphics format is completely standardized, computer makers can speed up graphics computations, particularly for the CRT, by incorporating a graphics processor—a specialized chip that takes the standard graphics-primitive instructions and creates the CRT image much faster than the computer's general-purpose microprocessor can. Such special-purpose chips also free the central processing unit for nongraphics tasks. Several companies have already built graphics processors; a simple chip designed by NEC, for example, is used in many video display drivers. MindSet (Sunnyvale, Cal.) used a custom unit in its near-clone of the IBM PC. The Amiga also has a custom graphics processor, but it works at an even lower level than VDI. Although the presence of a graphics chip does not guarantee success (MindSet recently filed for Chapter 11 bankruptcy protection), it's probable that most output devices, from CRT displays to printers, will eventually incorporate such a processor.

Microcomputers such as the Commodore Amiga can produce graphics once feasible only on expensive, specialized displays.

In the meantime, PC users can add graphics capability to their machines by acquiring specially designed plug-in printed circuit boards. The poor quality of IBM's original color display adapter board (640 × 200–pixel resolution) is glaringly obvious by comparison when the PC is enhanced by the 720 × 348–pixel monochrome display adapter from Hercules (Berkeley, Cal.) or IBM's color Enhanced Graphics Adapter (640 × 350 pixels). PCs are even beginning to function as workstations for computer-aided design and computer-aided engineering applications. But for such sophisticated uses, only expensive ($2000–$4000) adapters with at least 1024 × 1024 resolution will do. □ ***—Cary Lu***

DATABASE MANAGEMENT

Making facts easier to find

Microcomputer database management systems (DBMSs) are moving in several directions at once. At the high end, DBMSs for large computers are being scaled down to run on the new high-powered personal computers. In the middle range, conventional DBMS products like dBase from Ashton-Tate (Culver City, Cal.) and R:base from Microrim (Bellevue, Wash.) are becoming more powerful, more flexible, and easier to use. Meanwhile, programs that manipulate free-form text in the same way that traditional systems handle formatted data have appeared at the low end of the market. And the Apple Macintosh, with its high-resolution graphics capability, has engendered a new class of DBMS products that can store and access pictures in the same way that conven-

Johnny Ca

Last year, over a dozen national studies told the country what businesses have known for years.

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tional DBMSs handle data.

For easy access, most of the DBMSs for micros arrange data in a tabular matrix format, with rows of information representing individual records and columns representing specific record attributes, or fields. Thus a personnel file would have records on each employee, with fields for such information as first and last name, social security number, and salary. When users request information, the DBMS sequentially scans the tabular records searching for keywords that identify the desired material.

While they may arrange data in a common way, each DBMS product differs in the type and level of features it provides. Many products are in their second or third generation and have incorporated changes based on user reactions to the earlier versions. Responding to user demands can pose problems for the major manufacturers of database software, however, because the two biggest groups of users want different things. "At one end of the spectrum we have people who are more or less professional programmers," says Wayne Erickson, Microrim's CEO. "They are very sophisticated and are looking for more functionality and features. At the other end are people who have a job they need to do, but they never had to think about a database before." As a result, he says, the definition of a DBMS keeps expanding. Scott Brown, technical PR manager for market leader Ashton-Tate, agrees. "We've pushed the extremes out further," he says.

Many of the improvements are quantitative, not qualitative. Ashton-Tate's dBase III, for instance, can simultaneously work on data spread over 10 files, rather than just two, as was the case with dBase II. Most of the new programs also allow more records per file, more fields per record, and more characters per field than their predecessors.

Nevertheless, a key goal of recent DBMS releases has been to improve ease of use. Programs like dBase II, with a complex built-in data manipulation language, are capable of fairly sophisticated operations, but are hard to learn. To make life easier for novices without crippling the programs, many vendors now include features to automate difficult jobs such as setting up the database and designing report formats. The dBase III package has a module called dBase Assistant that lets the user operate the program by choosing menu options rather than by typing in commands.

As sophisticated DBMS programs get easier to use, they are moving into what used to be the exclusive domain of user-friendly products such as PFS:File from Software Publishing (Mountain View, Cal.). Until recently, products at this end of the database market performed simple record management and little more. Now, low-cost DBMS programs are appearing that exploit the growing power of microcomputers.

One of the most interesting trends is in the area of graphics databases that manipulate images as well as words and combine the two types of data on display screens or printouts. Products such as Helix from Odesta (Northbrook, Ill.) and Filevision from Telos (Santa Monica, Cal.) are designed to work with high-resolution graphics and are now available on the Apple Macintosh. With Filevision, for instance, an inventory program could include a map of the warehouse. When certain parts were needed, the program could highlight the location of each item. One Filevision demonstration program is a wine selector that highlights the location of wine bottles in response to requests such as "List all the wines ready to drink now that go with fish and cost less than $15 a bottle."

Text-oriented databases are another kind of DBMS receiving considerable attention. These programs combine features of word processors with DBMS features such as keyword search and indexing. One class of text databases—outline processors—organize information in topics and subtopics in the manner of conventional outlines. More sophisticated are free-form text databases, which may integrate word-processing software with DBMS software. In these programs, the database is a block of text that can be many pages long and contained in one or more text files. The software can search for and sort specific words or phrases in the same way a conventional DBMS manipulates tabular data fields and records. Text database systems now on the market include Factfinder from Forthought (Mountain View, Cal.) and the DayFlo free-form text database from DayFlo (Irvine, Cal.).

As powerful microcomputers begin to perform applications once addressed only by larger computers, some vendors are adapting DBMSs from these computers to run on the micros. Products like PC/Focus from Information Builders (New York) and ZIM from Zanthe Information (Ottawa, Ont.) "are basically microcomputer implementations of mainframe databases," says David Kalman, editor in chief of the *dBased Advisor* (San Diego), a magazine covering microcomputer DBMS developments. Unlike the older microcomputer database programs, these scaled-down DBMS packages support multiple users and can handle extremely large databases. They use formatting models and manipulation methods not yet common in the microcomputer world, and they are judged in large part on how closely they copy their large-computer predecessors. Most of them also feature elaborate data import and export facilities so they can exchange information with databases on large computers.

Ultimately, microcomputers will probably have enough power to knit all the DBMS trends together into a single program. This "superprogram" will be able to handle multimillion-record databases and import information from mainframes, have the software development features micro programmers want, be able to manipulate special data structures like free-form text and graphics, and have a user interface that lets even the least knowledgeable users get answers to complicated questions. But until such a product appears—perhaps in five or six years—users will have to choose the type of DBMS that best fits their capabilities and needs. □ ***—Rick Cook***

STORAGE DEVICES

Bigger memories, smaller footprints

Each year, the semiconductor industry finds new ways to pack more bits of data onto random-access memory (RAM) chips, which provide a computer's internal, most rapidly accessible memory. Costs, as a result, have plummeted: Five years ago, a 4K-bit RAM chip cost about $4; today, a 256K-bit chip costs even less. At the same time, the computer industry is boosting the capacity of peripheral data storage devices—flexible ("floppy") disks, rigid Winchester disks, tape systems, and optical laser disks—to a degree once thought impossible.

The additional data storage is necessary to meet the growing requirements placed on personal computer systems. In 1981 the IBM PC came with 64K (65,536) bits of internal memory and floppy disk drives that stored 360K bytes (eight bits per byte) of data. But running the popular Lotus 1-2-3 spreadsheet program requires at least 190,000 bytes of internal memory. Responding to the demands of such software, the newer IBM PC/AT has at least 256K of RAM, floppies that store 1.2 megabytes, and fast-access, 20-megabyte Winchesters.

In the peripheral storage sector, market demands are forcing manufacturers to increase the areal density of disks—the number of recording bits per square inch of surface area—and to reduce the size of the disks and their drives. Because "the key goal of computer companies is to shrink the computer's 'footprint' on the desk," says Ray Freeman, an industry consultant based in Santa Barbara, Cal., disks and drives are being cut to half their current size.

The 5.25-inch disk has been a standard in the personal computer industry for years, but both Apple Computer and Hewlett-Packard chose 3.5-inch floppy disks for their newest desktop computers, the Macintosh and the Touchscreen. Compaq, with its Deskpro model, this year became the first major PC vendor to use a 3.5-inch Winchester hard-disk drive that stores 20-megabytes of data—twice the capacity of the most widely used 5.25-inch Winchesters. "There's no doubt that in low-end computers 3.5-inch drives will replace 5.25-inch drives," says Jim Porter, a Mountain View, Cal., data storage expert and author of the *Disk/Trend Report*. But the conversion is happening slowly, because of the limited availability of application software offered on 3.5-inch disks. This shortage will probably persist until IBM adopts the smaller disk format, possibly for its long-awaited PC2. "Until IBM is firmly locked into a new standard, vendors are taking a chance by spending their money in that area," says Albert S. Hoagland, director of the Institute for Information Storage Technology at the University of Santa Clara in California.

Meanwhile, advances in recording technology should ensure the long-term survival of all types of magnetic media. Several companies are working on "vertical recording," for example, in which the magnetic particles on a disk line up vertically through the disk material instead of horizontally on the disk's surface, permitting more of them to be packed within a given area. Using this technique, companies such as Vertimas Systems (Minneapolis) have come close to doubling the number of recorded bits per square inch.

The growing memory capacities of PCs do have a disadvantage: They're aggravating the problem of data backup. Data and programs stored on nonremovable hard disks are routinely copied onto removable media so that they wouldn't be lost if the hard disk failed. Floppy disks can serve this backup function, but it's unwieldy to copy data from a 10- or 20-megabyte hard disk onto a slew of low-capacity floppies. One established solution to the backup dilemma it to use high-capacity "streaming" tape drives, which are designed to copy hard-disk data rapidly. Companies selling streaming tape drives include Cipher Data Products (San Diego), Archive (Costa Mesa, Cal.), and Western Peripherals (Tustin, Cal.). A more recent and even faster backup device is the Bernoulli Box, sold by Iomega (Roy, Utah). Each Bernoulli Box contains one or two removable 10-megabyte cartridges and operates at Winchester-like speeds. Aside from copying data faster than streaming tape, the random-access Bernoulli Box can access specific data faster than the tape backup, which must search serially along its length to find the desired information.

Hewlett-Packard's 3.5-inch micro-Winchester drive stores 10 megabytes of data.

Magnetic media are undergoing many technological advances, but they are no longer the only solution to peripheral storage. After years of laboratory development, laser-based optical disk drives have begun to appear on the market. Whereas standard magnetic media store data by magnetizing tiny particles on the disk or tape surface, most optical sytems write data by burning microscopic pits into a platter with a laser, and read by bouncing laser light off the pits.

The biggest selling point of optical storage is its unequaled capacity. Typical of the products under development is a drive unveiled in May by Optotech (Colorado Springs). Its Model 5984 optical drive weighs just five pounds and supports removable 5.25-inch disks that hold 400 megabytes each; the company claims that the whole package will cost about the same as a 40-megabyte Winchester drive. Optical disks have another advantage over Winchesters in that their read/write heads float much farther away from the disk surface than magnetic heads do. This minimizes "head crashes"—where the head breaks through its cushion of air and strikes the disk—and makes optical disks much more durable.

Yet the market for optical storage is uncertain. Researchers point out that storage capacity is only one factor that buyers consider. Another is access time—how long it takes to find and retrieve data. Optical read/write heads contain optical glass, laser diodes, and various other devices that make them much heavier and slower than magnetic Winchester heads. As a result, current-generation optical systems have much slower access times than Winchester drives. What's more, they can't be erased. Although prototype erasable disks have been developed, none are yet economical enough for use in the PC marketplace.

Still, optical storage will prove very useful in situations where the ability to gain reasonably rapid access to massive amounts of data and to store the

data economically for long periods of time is more important than instant accessibility. Financial firms, for instance, may want to keep audit trails or to track stock market performance for several companies; oil exploration firms have a similar requirement for seismic data. Optical drive vendors say their disks have a life of more than 10 years, twice that of magnetic media, making them very attractive for such archival applications. □ ***—Dan Beucke***

OUTPUT DEVICES

High-quality printing gets affordable

Microcomputer users now have a number of output options that once were available only to users of larger, more expensive computers. Printers and plotters that use thermal-transfer, inkjet, laser, and photographic techniques are now both low in cost and reliable. In addition, printers using the more conventional impact dot-matrix technology today benefit from greater print speed, improved paper handling, and decreasing prices.

"Impact matrix printing will continue to be the dominant technology for the next five years," predicts Ted Webster, president of Datek (Newtonville, Mass.), a printer market research firm. "It's what people are familiar with, the expendables [such as ribbons] are cheap, and the printers are dependable." IBM (White Plains, N.Y.) apparently agrees. After years of purchasing dot-matrix printers from Epson America (Torrance, Cal.) and remarketing them under the IBM name, it recently began manufacturing its own. The IBM Proprinter prints 200 characters per second (cps), handles individual sheet-feed as well as continuous-roll paper, and sells for a relatively inexpensive $549. "IBM has invested a huge amount of money to build the printer in Charlotte [N.C.] using robotics," says Webster. "They've gambled on the likelihood that impact matrix is here to stay."

Other manufacturers plan to withstand IBM's entry into their market by offering newer technology and added features. Impact matrix printers use print heads consisting of an array of needlelike hammers, or print wires, which strike a ribbon against paper to form dot patterns that constitute characters or graphics. Vendors are increasing the number of print wires to increase dot density and boost the quality of output. While still inferior to type produced by solid-character print mechanisms, high-quality dot-matrix output is far superior to that produced by the early generations of impact matrix devices. NEC and Dataproducts, among others, offer printers with 18-wire heads, and several Japanese vendors, including Epson, C. Itoh, and Toshiba, sell machines with 24-wire heads. IBM's 9-wire Proprinter can attain a respectable output of 240 horizontal and 144 vertical dots per inch by making multiple passes over each line, but at a considerable cost in print speed.

Impact matrix printers tend to be noisy, a disadvantage that has helped boost the popularity of the nearly silent inkjet printer. Also, while some impact matrix printers can produce color output by using a multicolor ribbon, inkjet devices generally provide better color. "By 1986, low-cost inkjet devices will offer letter-quality text and color graphics, all in the same product," claims Peter Testan, director of the Color Hard Copy Market Requirements Service at C. A. Pesko Associates (Marshfield, Mass.).

Currently, most color inkjet printers priced under $1000 use a printer mechanism manufactured by Canon (Lake Success, N.Y.). These include products from IBM, Radio Shack (Fort Worth, Tex.), and Quadram (Norcross, Ga.). The Canon inkjet mechanism employs a printhead consisting of four nozzles, one for each of the three primary colors plus black. Behind each nozzle is an ink chamber, the rear wall of which is a piezoelectric plate. An electrical impulse causes the plate to flex, forcing a drop of ink through the nozzle and onto the paper. Printers based on the Canon engine typically have a top speed of about 50 cps.

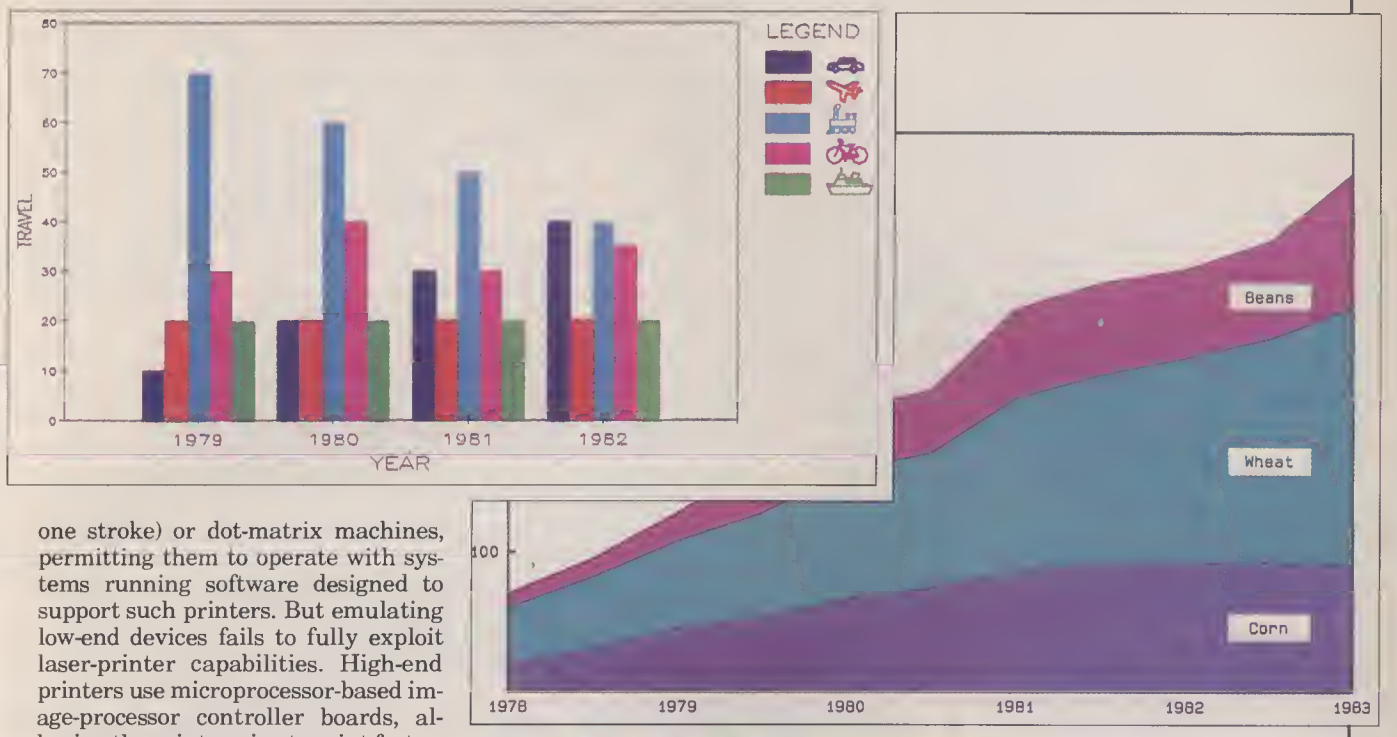
Bubblejet is another inkjet technology. Employed by Hewlett-Packard (Boise, Id.) in its monochrome ThinkJet, as well as by Canon in a recently unveiled prototype color printer, bubblejet print heads replace the piezoelectric plates used in conventional inkjet heads with a thermal resistor. The resistor rapidly boils the dye, forming a bubble that bursts, ejecting a droplet of dye onto the paper. Such print heads produce finer dots, allowing higher resolutions than conventional inkjet heads, and they print at higher speeds. HP's ThinkJet prints at 150 cps and sells for $495. Canon's high-end color version, to appear in late 1986, will reportedly print at 30 pages per minute.

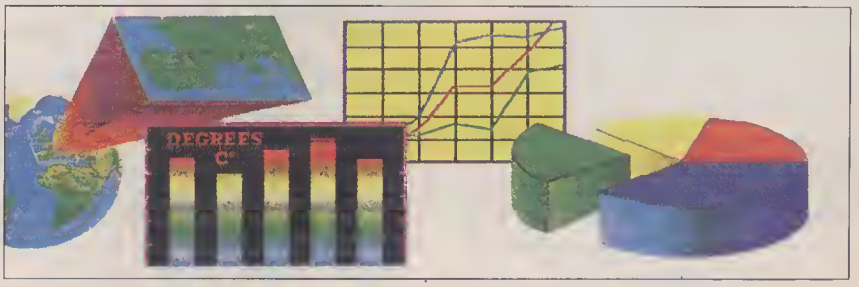
Another recently introduced inkjet technology uses solid, waxlike pigments heated into liquid form. Conventional piezoelectric print heads then eject the liquid ink to the paper, where it instantly solidifies. The result is dark, sharp characters without the fuzzy "wicking" that characterizes inkjet printers using thinner dyes. Exxon Enterprises (Brookfield, Conn.) and Dataproducts (Woodland Hills, Cal.) are jointly developing a monochrome printer based on this technology, and Howtek (Hudson, N.H.) plans a color version that will be manufactured in Japan by Juki Industries. Both printers, as yet unpriced, are slated for volume shipments next year.

Thermal-transfer printers also use solid pigments, but in the form of ink sheets or ink ribbons, and they use quick-heating thermal print nibs to melt the pigments onto paper or transparency material. The Okimate, made by Okidata (Mt. Laurel, N.J.), provides 144-dot-per-inch resolution, and prints in color. This type of printer works best with very smooth paper, foiling users who hope to print on company letterhead bond, and the expendable ribbons and sheets are relatively expensive. But at $239, the 80-cps Okimate is the cheapest color printer/plotter available. Ricoh (Fairfield, N.J.) recently introduced a thermal-transfer color plotter under $400.

At the upper end of the price spectrum are laser printers—traditionally far too costly for microcomputer applications. But a spate of new products, almost all based on Canon's LBP-CX print engine (the same mechanism used in Canon's disposable-cartridge Personal Copier line), are now available in the $3000–$10,000 price range. This is still too expensive for a companion device to a single personal computer, but it is suitable if the printer serves as a shared resource for several micros. Firms offering laser printers based on the Canon engine include Hewlett-Packard, Digital Equipment (Maynard, Mass.), Corona (Thousand Oaks, Cal.), Personal Computer Products (San Diego), Apple Computer (Cupertino, Cal.), Imagen (Santa Clara, Cal.), and Canon itself.

Laser printers at the lower end of the price range emulate daisywheel printers (which produce characters in





IBM's color Jetprinter can produce high-resolution graphs when running software such as Chart-Master from Decision Resources. Hewlett-Packard's inexpensive ThinkJet generates solid color areas much more effectively than an impact color printer could. The Okimate thermal-transfer printer produces color output that's limited in resolution, but it costs just $239.

one stroke) or dot-matrix machines, permitting them to operate with systems running software designed to support such printers. But emulating low-end devices fails to fully exploit laser-printer capabilities. High-end printers use microprocessor-based image-processor controller boards, allowing the print engine to print faster, at higher resolution, and with less CPU intervention.

Users desiring photographs of images on a personal computer's screen can choose from several low-cost slide makers. The Palette system from Polaroid (Cambridge, Mass.) sells for under $1800 and is compatible with IBM's PC/XT, AT&T's PC6300, and DEC's Rainbow. Employing a developer box and the same instant transparency film used by the company's cameras, the Palette produces reasonably good 35-mm slides. "For higher-quality graphics, you have to go a step up from the Palette," says Pesko Associates' Testan. Several companies, including Bell & Howell (Chicago), Laser Graphics (Irvine, Cal.), and Data Innovations (Lowell, Mass.), take the basic Polaroid Palette, modify the controller and software, and offer higher-quality systems costing $4200–$7500.

The oldest graphics hard-copy devices, pen plotters, are still the most popular. Such plotters have the highest resolution, provide local intelligence that relieves the microcomputer of some of its processing chores, and offer compatibility with a large base of graphics packages. One drawback is their slowness; even simple charts typically take three or four minutes to produce, limiting pen plotters' usefulness for high-volume output.

Developments in color copier technology, however, may offset this disadvantage and provide a boost for pen plotters and other color hard-copy devices as well. "The pen plotter may take 10 minutes to do a plot," says Testan, "but if you can run off 50 copies on the color copier, that's no longer a problem." Ricoh, Toshiba (Tustin, Cal.), and Sharp (Paramus, N.J.) all plan to introduce low-cost color copiers soon. According to Testan, demand for such copiers is already quite high. "By the end of 1985," he says, "there will be over a million color hard-copy devices installed in the U.S. market, and those devices are all creating originals that need to be duplicated." Once color office copiers become widely available, he concludes, color hard-copy output devices will see an even greater upsurge in demand. □

—Bob Hirshon

NETWORKING

PCs start talking over links and LANs

No man is an island, and these days no personal computer should be an island either. That's why corporate PC users are clamoring for local-area networks (LANs), which let PCs talk to each other and to other devices, and for micro-to-mainframe links, which feed desktop computers information from centralized databases. LANs and links are popping up in many corporations, but most potential buyers are still waiting for clearer trends to

emerge before committing to a specific product or approach.

The LAN industry is riding a modest boom in the face of the computer slump, as corporations search for ways to crank out productivity gains from their prior investments in PCs. The number of installed LANs purchased is expected to jump from today's 80,000 to over 200,000 by 1990, according to Barry Marks, vice-president of consulting services at the Eastern Management Group (Parsippany, N.J.). But not surprisingly, many potential LAN customers are waiting to see what IBM will do in this area. So far the computer giant has moved excruciatingly slowly, and in several directions. IBM has brought out a simple computer cabling scheme, as well as a sort of mini-LAN called the PC cluster and a multichannel broadband LAN called PC-Net, supplied by Sytek (Mountain View, Cal.). But even the full-function PC-Net is seen by many as merely a stopgap product, and announcement of a more sophisticated LAN is expected any day.

While IBM's LAN products, like all its others, will attract widespread industry support, the company's lead could be challenged somewhat by AT&T's planned LAN offering, Starlan. Unlike IBM's cable-based LAN, Starlan will run on the unshielded twisted-pair wiring already installed in many offices. By tapping into this existing network, Starlan will cost only about $200 per node to install, versus $1000 per node for PC-Net. It is also more versatile, supporting multiple networking protocols such as General Motors' Manufacturing Automation Protocol, which is rapidly becoming a standard for factory LANs. Furthermore, Starlan's star topology (with PCs radiating from a central node) permits easier integration with the similarly configured digital phone PBXs than does the ring topology of IBM's expected LAN. But Starlan is slower and, even if successful, will probably have to provide full compatibility with IBM networking hardware and software.

IBM and AT&T may eventually dominate the LAN marketplace, but for companies shopping today there are many attractive alternatives. For example, Proteon (Natick, Mass.) has a LAN that is 40 times as fast as PC-Net; Novell (Orem, Utah) has brought out a fault-tolerant LAN; and Apple (Cupertino, Cal.) plans to offer its AppleTalk LAN for a bargain-basement $50 per node (for Macintoshes). Still the most popular LAN is Xerox's Ethernet, an old-timer supported by a large number of vendors even though its single-channel baseband technology is limited in the amount and type of information it can carry compared with the multichannel broadband approach. Because of Ethernet's widespread acceptance, even IBM will probably be forced to announce an interface between its LANs and Ethernet networks sooner or later.

But the wide range of LANs available have yet to overcome a major factor inhibiting their growth: the general lack of applications software designed to run on networks. Such software is starting to appear on the market, but only gradually. In the meantime, companies operating LANs must make do with software designed to run on stand-alone microcomputers, a less than optimal solution. Stand-alone software, by definition, has no mechanism for accessing other equipment over the network, and it has no built-in protection against such dangers as network users disrupting or destroying each other's data files. Software specifically designed for network use addresses these needs, which must otherwise be met by special software, and most observers believe the LAN market won't really take off until such network applications are widely available.

Users are demanding that they not be isolated from the rest of the computer world

Those looking for a micro-to-mainframe link also face a confusing marketplace. At the lower end, several dozen companies sell add-in boards and programs that let PCs talk to a host computer as if they were mainframe terminals. Available for a few hundred dollars per PC from companies like Digital Communications Associates (DCA—Atlanta) and IdeAssociates (Billerica, Mass.), these terminal emulator packages permit only simple file transfers between the mainframe and the PCs, and they won't do much for users who aren't familiar with mainframe access procedures.

At the high end of this market are link products that automatically perform the mainframe access and present data to PC users in PC-like form, in some cases even loading up their spreadsheets. But the most sophisticated mainframe software packages don't come cheap; those from vendors like Applied Data Research (Princeton, N.J.) and McCormack & Dodge (Natick, Mass.) can cost well over $100,000 for a 50-PC setup.

An increasingly popular compromise is file transfer and translator programs, which require only a limited amount of user education and installation effort. Once the link has been established, these packages can ship files back and forth between PC and host, providing all the translation and reformatting necessary. PcMainframe from Oxford Software (Hasbrouck Heights, N.J.) handles a configuration with a host and eight PCs and costs $9000; a 10-PC package from Linkware (Waltham, Mass.) is relatively expensive at $30,000, but can be expanded to allow file compatibility between almost any type of host. Other packages are usually restricted to a few types of mainframe.

One helpful trend in this area might be the increasing number of joint ventures being formed between PC software houses and mainframe link vendors. Lotus Development (Cambridge, Mass.) has separate agreements with DCA and mainframe software vendor Cullinet (Westwood, Mass.) to integrate its Symphony package with links from these firms. Also, some vendors of popular mainframe application packages are bringing their software out in PC versions that can communicate with the mainframe. The PC version of Focus, a widely used database management system and application development language from Information Builders (New York), is a best-seller. The most welcome news of all might be the availabilty of integrated LANs and links that can fetch information whether it's in the PC next door or on a mainframe across the country. Banyan Systems (Westboro, Mass.) is an early leader in providing such total integration.

In fact, one of the hottest areas in data communications is the market for products that link different types of LANs to one another, as well as to long-distance networks. Even if some marketplace consolidation occurs, it seems certain that various types of LANs will have to coexist for some time. Users are therefore demanding that they not be isolated from the rest of the computer world by their choice of networking technology. □

—David H. Freedman

Westinghouse brought in TI's Personal Consultant™ because these experts don't have time to waste.

Personal Consultant is the expert systems development software that's turning the time they spend answering routine questions into research and development.

Dr. Neil Pessall and Dr. Jan Schreurs, research scientists at the Westinghouse Research and Development Center, had a problem. How could they make hundreds of man-years worth of practical knowledge at the Center readily available to Westinghouse and its customers, without pulling the scientists away from their research to answer routine questions?

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Designed to run on 512K-Class Personal Computers, Personal Consultant provided Westinghouse an eminently affordable new tool for the development of expert systems. Pessall and Schreurs were especially impressed with its ability to aid experts in developing the knowledge bases and prototyping programs which even first-time computer users could consult for expert advice.

"With Personal Consultant software," says Schreurs, "we found it far easier to teach our experts how to develop a system than teach a programmer to be an expert." In fact, the software's rapid expert system prototyping and simple debugging features enabled the two scientists to demonstrate three different expert systems in as many weeks. Schreurs produced one for training new salespeople and a second to guide repairs and maintenance for the Center's X-ray defractometer.

Pessall's makes material recommendations for tubes and support plates in steam generators.

"Our development of expert systems isn't aimed at replacing experts," says Dr. Pessall. "Its purpose is to give them the time to extend their expertise while the expert systems handle consultations on well-established knowledge and methodology."

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The microcomputer is making itself useful in every walk of life—from designing buildings to teaching anatomy.

BUSINESS

Networking: big office seeks big gains

Boston's Bain & Co. doesn't intend to let computer technology pass even one of its 600 professional employees by. The business consulting firm, which specializes in strategic planning for Fortune 500 companies, expects to have a personal computer—either an IBM PC or one of its top-of-the-line siblings, a PC/AT—on almost every desk by the end of 1986. Soon after that, according to Bob Sikkema, the company's office-automation group leader, most of the computers should be linked by one or more local-area networks (LANs) so they can communicate with each other and share information stored in a variety of company databases.

Sikkema has already started putting the grand plan into effect at the Boston headquarters. Last November, Bain began installing a LAN specially designed for personal computers (the Personal Connection from Ungermann-Bass in Santa Clara, Cal.); 45 IBM PC/ATs have already been attached, and plans call for a modest but steady number of additions each month. To become part of the network, a computer must first be fitted with an Ungermann-Bass circuit board that allows it to transmit and receive data according to the network's traffic rules. The board is then plugged into a coaxial cable, which physically links all the computers and peripheral devices. Eventually, says Steve Bilotti, data center administrator, the network will also tie in two Digital Equipment VAX minicomputers that house Bain's large databases of client information and internal company records. For now, though, each PC must be wired individually to the VAXs (with ordinary telephone wire) for access to this information.

Both the network itself and the computer applications it will help coordinate are still evolving, says Sikkema. But the company hopes that eventual uses will range from analyzing business and financial data for clients—making "what if?" calculations to produce various strategic scenarios—to performing such internal chores as billing staff time to client accounts. Bain also has long-range plans to tie its offices in London, Munich, San Francisco, Paris, and Tokyo into the network for closer communication with the home office. And it will implement electronic mail to let employees send messages and distribute memos over the network as soon as the necessary software is developed for the Personal Connection LAN.

Until these plans are farther along, however, employees will use their computers much like stand-alone machines, primarily for report writing, correspondence, and financial analysis. "We have very little file sharing and no shared tasks at this time," says Sikkema, because techniques for transferring data directly from one PC to another have yet to be implemented. The data that can currently be shared is limited to files stored on a hard disk attached to the micro designated as network file server; special software allows several PCs to use these files simultaneously.

Although many of its benefits have yet to be realized, the system is paying off in some ways even now. "The network was put in primarily for cost savings," says Sikkema—savings made possible by the sharing of expensive peripheral devices such as printers. Before the network was installed, each of the company's microcomputers had its own printer, but Sikkema estimates that these were idle more than 90% of the time. Now each computer on the network has access to several letter-quality Hewlett-Packard laser-jet printers. With one printer for every 10 computers, the expensive devices are in use almost all the time. □ *—Anne Knowles*

Sales force plugs into home office

The nationwide sales staff for Wrangler's Womenswear used to have a tough time keeping track of inventory, what with over 400 different styles of clothing, each produced in three colors and four sizes. Sales peo-

BRIAN SMITH

For users of Jim Muller's AlphaGraphics do-it-yourself typesetting system, what they see is literally what they get.

ple often ended up writing orders for out-of-stock items—sometimes making customers wait weeks for delivery—while similar styles that could have been substituted gathered dust in the company's warehouse. But Womenswear began to solve the problem last February, when VP of sales T. E. Ormsby armed his sales force with portable computers that can communicate directly with a mainframe in the division's Greensboro, N.C., headquarters.

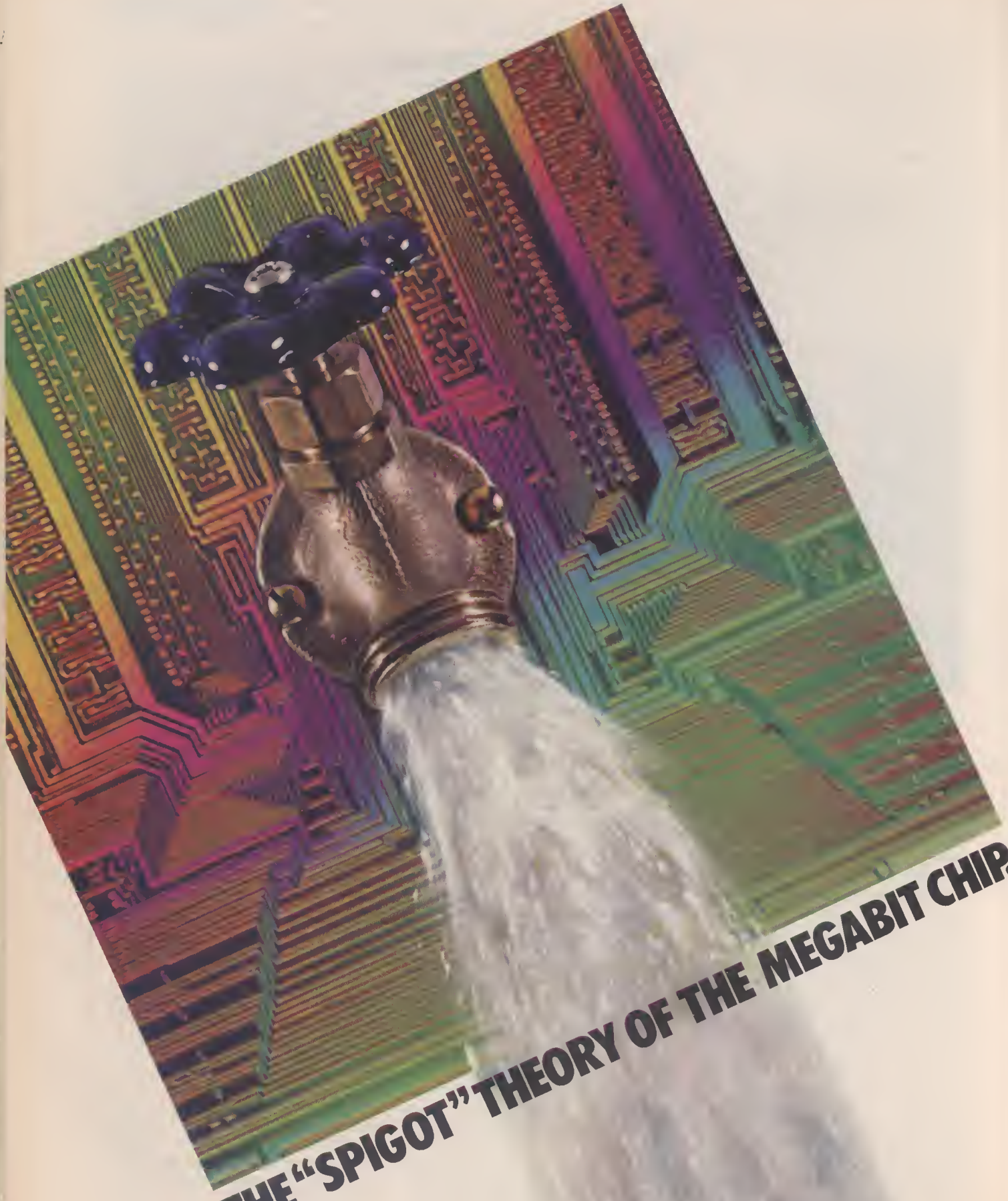
Each of the 100 sales people now carries a briefcase-size Sharp 5000 equipped with custom software developed by Sales Technology (Atlanta). "Our first priorities," says Ormsby, "were that the staff have up-to-the-minute inventory data and be able to generate an order immediately." Using their portable computers, the sales force can tap into the mainframe's database via phone lines—right from a customer's office—to get a list of stock available for shipment and to place an order on the spot. The sales staff can also use the computers to send messages and reports to the home office, says Ormsby, and will soon have software to help keep track of travel expenses and enable them to submit expense reports to headquarters electronically. □ ***—Anne Knowles***

Quick-print shop adds do-it-yourself typesetting

In the AlphaGraphics chain of quick-printing shops, customers can typeset and lay out their own jobs—headlines and all—on the screen of a personal computer, which then produces an actual master (for offset printing or photocopying) in just seconds. This is made possible by a new generation of inexpensive laser printers that can be hooked up to PCs with easy-to-manipulate but very powerful graphics capabilities.

Since April, AlphaGraphics (based in Tucson, Ariz.) has been installing do-it-yourself typesetting systems in its new franchises, which it is opening at the rate of four a month, and it plans to convert two a month of its 100 or so existing stores. Each franchise gets a system with two Apple Macintosh computers, software, an Apple Laserwriter printer, and a machine that converts floppy disks from other computers into a format that a Macintosh can handle. Whereas most PCs display only typewriter-style characters on their screens, PCs like Macintosh show a variety of typefaces, each in a range of sizes and with proportional spacing. Moreover, the laser printers produce near-typeset-quality text and let customers mix typefaces and sizes on a single page.

Customer response has been "phenomenal," says Jim Muller, owner of a franchise in Rancho Bernardo, a San Diego suburb. He reports that customers choose the less expensive do-it-yourself option about two thirds of the time (instead of having one of the staff do typesetting and layout) to produce everything from club bulletins to technical documents. "People just love to design and create on this,"



THE "SPIGOT" THEORY OF THE MEGABIT CHIP.

There are megabit chips. And there are megabit chips. All of them can access more than 1 million bits of information. But not all of them can access these 1 million bits of information AT&T fast. And fast to AT&T is 20 million bits per second.

That means we can pour out 1,048,576 bits much faster than you can say "byte." And we can do it because only the AT&T megabit chip has a fast column access mode.

The "Trickle-Down" Theory Vs. The "Spigot" Theory

Most other megabit chips use a "page mode" to access their memory cells. When a chip is in this mode, its fastest data rate is about 10 million bits per second.

But the fast column cycle, developed by AT&T Bell Laboratories, pours out data twice as fast. And not only does data flow out faster, getting data out is easier with the fast column, because access timing requirements are less demanding. Valid data are always available during the entire access cycle.

And speed, ease of use and timing tolerance will make it easier for AT&T to design new and improved products and high-speed systems around the megabit chip.

The Megabit Special

Because this megabit chip is designed for manufacturability, you might want to know what, besides its fast column, makes it special. It's made using an advanced CMOS—Complementary Metal-Oxide Semiconductor—process that makes it possible to provide high performance at reduced power consumption.

As a matter of fact, it uses 1/8 the power per bit of most 256K DRAMs. The lower power requirement is a plus for any system using the megabit—allowing for lower operating costs and reduced cooling requirements.

The AT&T megabit chip is smaller than a dime, yet has more than 2 million elements on it. Among those 2 million-plus elements are more than 20,000 spare memory cells for safety's sake. If for some reason there's a bad cell in a chip, a computer-controlled test targets the cell—and its whole row or column—for replacement. A laser redundancy technique, pioneered by AT&T, then disconnects the offenders and automatically replaces the entire memory row or column from the spares.

Actual size

Cleanliness Is Next To Goodliness

A speck of dust on a megabit chip is like a boulder on a railroad track.

To keep our chip clean, it has to be made in a room that's C-L-E-A-N. And an AT&T class-10 clean room is one of the cleanest rooms in the world—where the air contains fewer than 10 particles of dust in a cubic foot of air. And the largest particle must be smaller than 1/150 the diameter of a human hair. That makes our room 10,000 times cleaner than a hospital operating room.

To keep our air clean, we have to keep it moving. Ours is constantly circulated and filtered by fans that could inflate the Goodyear blimp in only 30 seconds.

You Ain't Seen Nothing Yet

Looking toward the year 2000, today's technology predicts submicron design widths, with lines only 400 atoms wide. Chips containing 100 million components—50 times the current amount—could have tiny regions with capabilities that more than match the megabit chip.

Now we're talking computer POWER, because these new chips with micro-parts could work at picospeeds (trillionths of a second). Current estimates suggest 10-picosecond transistors.

AT&T will not let the chips fall where they may. We'll put them where they'll do the most good—in the powerful and reliable digital systems creating the general-purpose information technology we call Universal Information Services. Our continuing flow of advanced technology is one reason why AT&T is the right choice.

AT&T

The right choice.

he says. Muller estimates that do-it-yourself typesetting constitutes about 60% of his quick-printing business and half of his copying work. And because demand is growing, he is planning to supplement the store's original three workstations with two more and intends to add new typefaces and extra features to the system.

While the AlphaGraphics system is designed for fairly simple documents (it doesn't allow free-hand drawing or lay out pages automatically), Muller's shop also sets most of the type for two local newspapers that have no typesetting equipment of their own. The papers, which have their own Macintoshes, can bring computer disks to Muller's shop to set type and create ad headlines right until press time. "It's here, it's handy, and in five minutes you have your type set," says Renee Garza, co-owner of the *Rancho Bernardo Sun*, one of the papers that use the service. Although she adds that the laser printer doesn't produce sharp enough images for high-quality ads, she deems it "fantastic" for text copy. The availability of low-priced printers, she declares, is "causing a revolution in the typesetting industry." □ ***—Rick Cook***

Going to the office—without leaving home

Michigan attorney James Eidelman learned the value of telecommuting the hard way, after a serious auto accident left him with a broken leg and hip. To keep up with his case load during recuperation, he relied heavily on his portable Compaq computer to write briefs, search legal databases, and communicate with the Ann Arbor, Mich., office of his law firm, Ulrich Pare Barense Eggan and Muskovitz.

Now that he's back on his feet, Eidelman enjoys the best of both worlds. At the office, he uses the firm's two Compaq computers for tax planning, generating financial spreadsheets, and organizing files. And at home—at least whenever he can wrest his own Compaq away from his son—he scans electronic bulletin boards and databases for legal information on trademarks, labor relations, and healthcare, among other subjects, and he experiments with new software and works on articles and briefs.

Even before the accident, Eidelman had joined the rapidly swelling ranks of executives and professionals who bring disks—and in some cases computers—home at night and on weekends. "I was always hauling them around," he says of the firm's personal computers, before he decided to buy his own. Eidelman also uses his home computer to do independent consulting and to write a monthly computer column for the *Michigan Bar Journal* and articles for an American Bar Association newsletter. Overall, he estimates, most of his home computer time goes to sustained writing, away from the endless succession of meetings and phone calls that make serious concentration so difficult at the office. □ ***—Mary Jo Foley***

Moving the ship of state a little faster

Unsuspecting visitors wandering by room 2230 of the Rayburn House Office Building in Washington, D.C., might think they had stumbled onto a secret Apple Computer showroom. It is actually the office of Rep. Charles Rose (D-N.C.), a self-proclaimed technology buff and computer aficionado, who has supplied himself and his staff with eight Macintosh personal computers, five high-speed dot-matrix printers, and a laser printer capable of producing near-typeset-quality print in a variety of styles and sizes.

The staff uses the computer equipment to streamline all the tasks that traditionally keep congressional offices open from dawn until well past dusk. For example, aides routinely tap into several on-line databases over telephone lines to do research for proposed legislation or political speeches and to monitor various bills as they move through House and Senate committees. The office has a direct line to the House Information System, a mainframe-based network that includes databases on legislation, Supreme Court action, and federal grants. For more general information, aides can use a modem to tap into public commercial database services.

To keep track of the congressman's crowded schedule of meetings, speaking engagements, and official events, the staff members use a calendar program. And they use word-processing software to speed up campaign mailings, handle correspondence, and generate a newsletter for constituents, among other regular tasks.

Rose himself has a Mac on his desk and has bought another to use at home to catch up on correspondence and write drafts of official documents. Each of the congressman's district offices in North Carolina also has a Macintosh linked with Rose's Capitol Hill office via phone lines and electronic mail software. Marc Williams, an aide who has helped Rose install and oversee the system, says he was originally worried that staff members would have difficulty adjusting to the Mac. Instead, he recalls, "they took to it immediately."

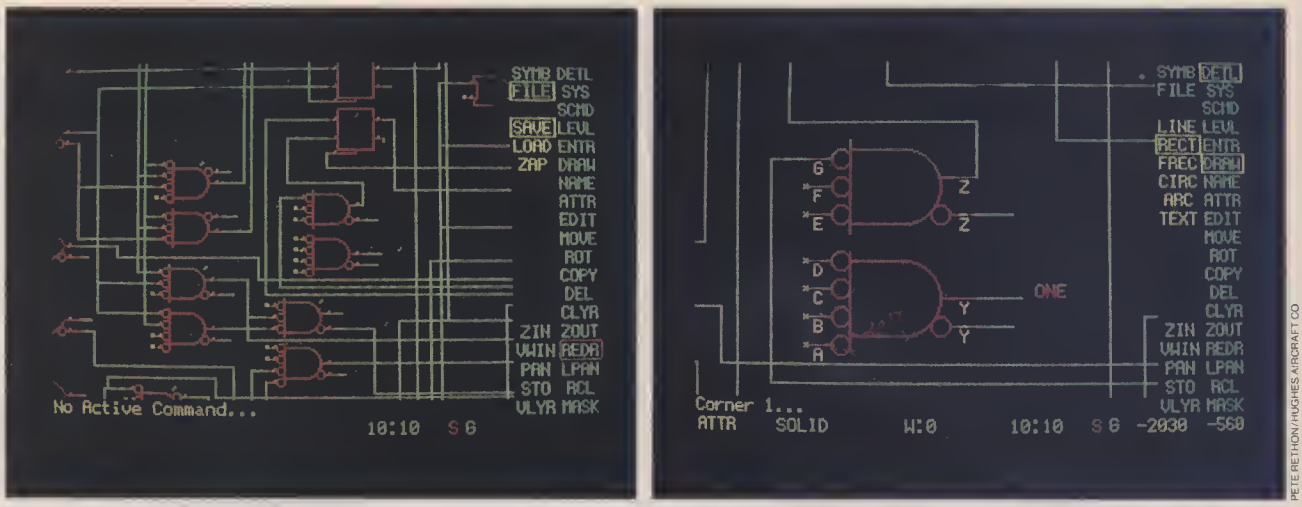
Rose chose the Macintosh because he considered it particularly versatile. He estimates that there are nearly 4000 terminals in the offices of Capitol Hill (including congressional staffs and agencies), the vast majority of them IBM PCs. □ ***—Mary Jo Foley***

TECHNICAL

Speeding chip design

A growing number of systems engineers are using personal computers and computer-aided design/computer-aided engineering (CAD/CAE) software to design integrated circuits. Among them is Steve Brunner—a senior systems engineer with Hughes Aircraft's Ground Systems Group (Fullerton, Cal.)—who designs gate arrays for use in military communications systems. "It used to take from 20 to 60 man-weeks to design a 4K to 6K gate array, depending on the complexity," says Brunner. "Using an IBM PC/AT with software from Personal CAD Systems [P-CAD—Los Gatos, Cal.], we save from four to six man-weeks per design."

The typical Hughes design workstation consists of an IBM PC/AT or PC/XT with 640 kilobytes of internal memory, a 10- or 20-megabyte Winchester hard disk, a mouse pointing device, a color monitor, and a graphics adaptor board that provides 640 × 350–pixel resolution. "Our 20-person Advanced Technology Laboratory now has seven ATs and four XTs," says Brunner, "and we're seeing such design shops proliferate all over Hughes." The PCs are not yet linked together, but a network is planned for the near future.



PETE RETHON/HUGHES AIRCRAFT CO

With the CAE-2 package, Hughes engineers can design complex gate array layouts (left) and zoom in for detail work (right).

Before acquiring the PC workstations, Brunner and his co-workers had to draw the schematic by hand, assign a name to every node in the circuit, and manually generate the netlist (the list of circuit parts and their point-to-point interconnections). The process was not only time-consuming but also prone to errors in transcription, typography, and logic. With CAE-2 software from P-CAD, the engineers now perform the bulk of this work on the PC, which markedly improves both accuracy and design time.

The PC workstations also bring considerable cost savings. Previously, an engineer might work at a "dumb" terminal, communicating over phone lines to a chip vendor's mainframe computer in order to perform much of the gate-array design. Timesharing costs on the mainframe alone could sometimes run as high as $40,000 per design. Some $10,000 worth of computer time can now be lopped off these costs by using a PC-based workstation, according to Brunner. And because a workstation with CAE-2 software costs only about $14,000, he says, "the system practically pays for itself with the very first design."

Personal computer–based CAD/CAE systems do have limitations, however. They serve in Brunner's shop essentially as front-end processors to the chip vendor's mainframe. The mainframe continues to do the physical routing (placement and connection of the parts on the integrated circuit), post-route logic simulation, and timing analysis. It also creates the pattern generator tape that provides information for the photolithographic process used to produce the ICs.

"But we can do all the schematic capture, local logic simulation, and design verification on the PC," says Brunner. P-CAD also sells a "library" of standard gate-array designs supported by Motorola and LSI Logic, two major chip manufacturers. The Hughes Aircraft designers can use these "standard cells" to ensure that the integrated circuit they're building will conform to the manufacturer's specifications.

Hughes has also discovered that the design workstations can double as office automation tools. "The engineers here are also using their PCs for word processing, spreadsheet analysis, database management, and program management," says Brunner. "And it's a lot easier to justify the purchase of this equipment under the guise of office automation, which will pay back its costs within a year, as opposed to buying larger CAD/CAE workstations, which cost from $80,000 to $150,000 and have economic paybacks stretched out over several years." □

—Daniel P. Schlosky

Automating a research lab

In the busy laboratory of Exxon's research and engineering division (Clinton Township, N.J.), personal computers "have literally saved work-years of time" in carrying out dozens of routine tasks, says Jeffrey Lemanowicz, a senior staff engineer at the facility. PCs have been particularly valuable, he says, in the collection and workup of data and in the preparation of graphics. In addition, the computers have made dial twiddling on complex instruments virtually obsolete. Experimental parameters are now keyed into PCs in response to prompting questions that appear on the screen; the computers then automatically set these parameters on the instruments.

In one typical procedure at the Exxon lab—a material analysis technique called thermal desorption—a PC is involved in nearly every phase. In this process a metal, ceramic, solid catalyst, or other material is exposed to carefully controlled mixtures of gases in a chamber. Scientists then analyze any chemical reactions that have occurred on the surfaces of the materials by slowly heating them and monitoring the gases they emit. A PC (typically an IBM PC/AT) not only regulates the gas inlet valves to the chamber but also controls the "ramping" (gradual rise) of the temperature as the sample is heated. When the sample emits gases, they are channeled to a mass spectrometer, an instrument that identifies components on the basis of how they fragment when bombarded by an electron beam. The resulting gas composition data are recorded by the same PC used to set the initial parameters. Results can be presented almost immediately, either digitally or graphically on the computer screen or pen plotter, giving users a real-time picture of the reactions. The data are also stored on disk for future reference.

Although the Exxon lab carries on an enormous range of experiments, it uses only a few types of computers. The IBM PC/AT is rapidly becoming the standard, reports Lemanowicz, but other small computers such as the Digital Equipment MINC and the Hewlett-Packard desktop model 9836 also serve in specific applications. To enhance the versatility of the PC/ATs and allow them to perform many tasks at once, the Exxon staff has souped them up with various equip-

ment. One add-on is an "intelligent front end," a microcomputer with slots for various boards that can be mixed and matched for different applications. The front end does preprocessing of data—converting units from millivolts to degrees centigrade, for example, or sounding an alarm when temperatures get too high—freeing the rest of the computer for higher-level tasks such as analyses, graphics, or interfacing with a mainframe computer.

Lemanowicz calls the Exxon facility's software a toolkit, because it consists of a general-purpose core program bundled with a set of more specialized features. Researchers design tailor-made programs by selecting the software "tools" appropriate to the tasks at hand. While much of the software, as well as the intelligent front end, has been developed in-house, Exxon is also starting to use some commercial programs such as Lotus 1-2-3.

While time saving is the most obvious benefit of the PCs in the lab, they also "open up new vistas" for researchers, says Lemanowicz. Because the staff needn't keep their eyes glued to instrument controls, the computers "allow them to think about what the data actually imply." The PCs also permit scientists to run more cases, improving the reliability of their data. "I don't know if you can put a dollar sign on these things," he says, "but they're extremely important." □

—Gordon Graff

Machine design made simple

Computer-aided design (CAD) programs for mechanical design have generally been so large and complex that only mainframe computers or superminicomputers could run them; until recently, personal computers had neither the computational power nor the memory capacity required. Now, says market researcher Bruce Jenkins of Daratech (Cambridge, Mass.), two- and three-dimensional wire-frame design systems are finding wider acceptance in PC-based mechanical design, thanks to the combination of improved PC performance and specially developed software. Wire-frame systems create images by using groups of lines and polygons to form transparent representations of objects; the more complex solid modeling packages are only slowly gaining a foothold.

Owens-Corning Fiberglas (Toledo, Ohio)—a company with a substantial body of large-system CAD experience—is increasingly relying on PC-based CAD systems to design much of the machinery used to produce fiberglass for applications such as insulation, automobile bodies, boat hulls, and tub and shower enclosures. A typical CAD application—the design of a complex conveyor system, for example—uses standard parts, such as motors, gearboxes, chains, and rollers, drawn from a parts library developed by Owens-Corning's corporate engineering center.

Long a user of CAD systems and workstations from Computervision (Burlington, Mass.), Owens-Corning recently began training its mechanical design engineers in the use of Computervision's Personal Designer systems. Owens-Corning has eight of the IBM PC/AT–based systems: two at the corporate engineering center in Toledo and the others at six different plant locations. According to Computervision, complete Personal Designer systems range from $13,000 to $18,500 including hardware and software.

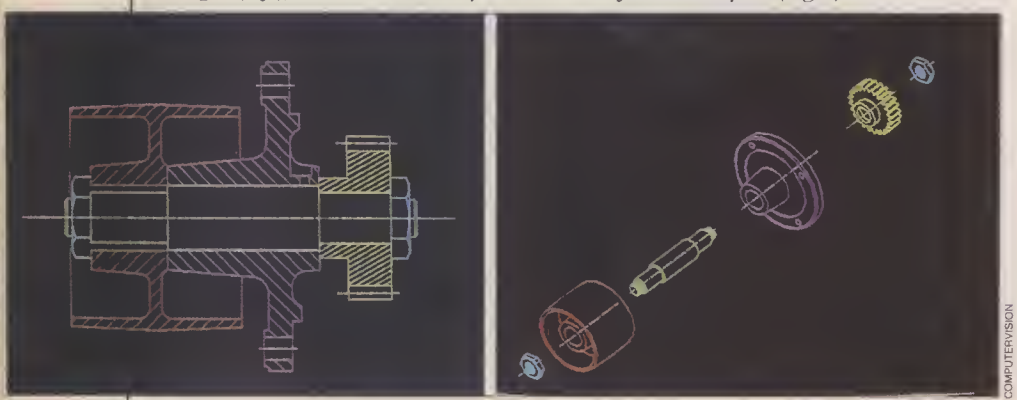
Owens-Corning had also considered PC-based systems such as AutoCAD from Autodesk (Sausalito, Cal.), VersaCAD from T&W Systems (Huntington Beach, Cal.), and SuperCAD from Tasvir Corp. (Mountain View, Cal.). All the systems have similar capabilities, says Robert S. Schaefer, director of design engineering services, but only Personal Designer let Owens-Corning network the PC workstations with its existing Computervision CAD systems and integrate the PC designs into the corporate database. Owens-Corning further intends to share this database with each of the plants using Personal Designer. "For a large company with several design groups at manufacturing plants, exchanging and maintaining design data is critical," says Schaefer.

Despite some initial delays in linking Personal Designer with other systems—software for file transfer, for example, and for enabling the PC workstations to act as terminals for the larger computer-aided design systems has only recently become available from Computervision—Schaefer admits to being pleasantly surprised by the performance of the PC workstation. "We've found the PC/AT can match the dedicated Computervision workstations in speed of response for designs with up to 1500 entities (such as points, lines, and polygons)." Productivity gains are significant, too, he adds. Schaefer has thus become an avid supporter of PC-based CAD. "The PC is now a very economical way of getting into mechanical CAD, even for small companies," he says. "So my advice to those standing on the sidelines is to get onto the learning curve right away."

Each of Owens-Corning's Personal Designer workstations currently has several engineering users; some also run Computervision's Personal Architect CAD programs and perform architectural design. Within a couple of years, Schaefer envisions having at least one PC/AT—or possibly a higher-performance personal computer—for every two design engineers. Schaefer's group has instituted a two-week course to introduce engineers to Personal Designer, but he estimates that "it takes about three months to become really familiar with the system—to get 80% of the way up the learning curve." Indeed, the advanced options available with Personal Designer for surface modeling and finite element analysis have been little used so far, although Schaefer anticipates that, in time, both packages will be employed extensively. □

—Jeffrey N. Bairstow

Computervision's Personal Designer systems let Owens-Corning engineers see 2-D designs (left), as well as 3-D exploded views of the same part (right).



COMPUTERVISION

A plot to track ocean-current dynamics

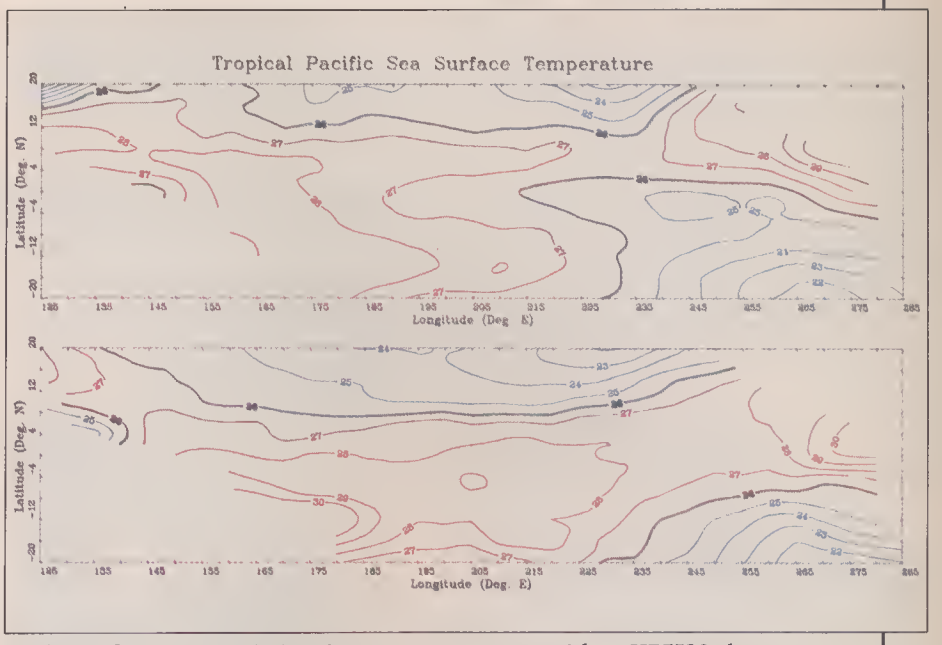
"Most people, especially engineers, don't think of the IBM PC as a really capable graphics workstation," says Michael L. Van Woert, research oceanographer for SeaSpace (San Diego). But SeaSpace runs a complex graphics application that has the potential to convert some of the skeptics.

Using satellite data, the company studies water temperature just below the ocean's surface and air pressure just above it to identify distribution and circulation patterns, which help guide the fisheries industry and assist meteorologists in making better weather forecasts. To clarify the patterns, SeaSpace uses IBM PC/XTs to convert megabytes of satellite data into charts, maps, and graphs—a task that the company used to perform on large minicomputers. A Hewlett-Packard HP9000 minicomputer is needed to break down raw data into a manageable database, but PCs perform all analyses and graphics representations.

While SeaSpace finds small computers equal to the task of processing the data, it requires big plotters to turn them into charts. "People laugh and ask, 'Why do you have such a big plotter hooked up to such a little computer?' " says Van Woert (his unlikely-looking graphics workstation includes a three-foot-wide HP7586). "But the PC drives it just as fast as a Cray supercomputer could. The plotter operates at 9600 baud, and the PC outputs data as fast as the plotter can take it."

Tying the PC and plotter together is a $250 graphics software package called Plot88 (from Plotworks in San Diego) that allows scientists and engineers to take existing graphics software written for mainframes and minicomputers and run it on PCs. "Without the Plot88 package, the whole thing would be off," says Van Woert.

Van Woert transmits needed data from the HP9000 to his personal computer by telephone, using a Hayes modem. He then runs statistical analyses of the data and makes plots in a variety of forms, ranging from simple *x-y* graphs to intricate contour maps. "Then I'll spread the drawings out on my floor and shuffle them around," he says. "If it appears that what I'm looking for is there, I can replot it to try and make it more obvious. There are a number of different analysis tools I can use for finding things, but it's generally like looking for a needle in a haystack."



SeaSpace charts time variations in ocean temperatures with an HP7586 plotter.

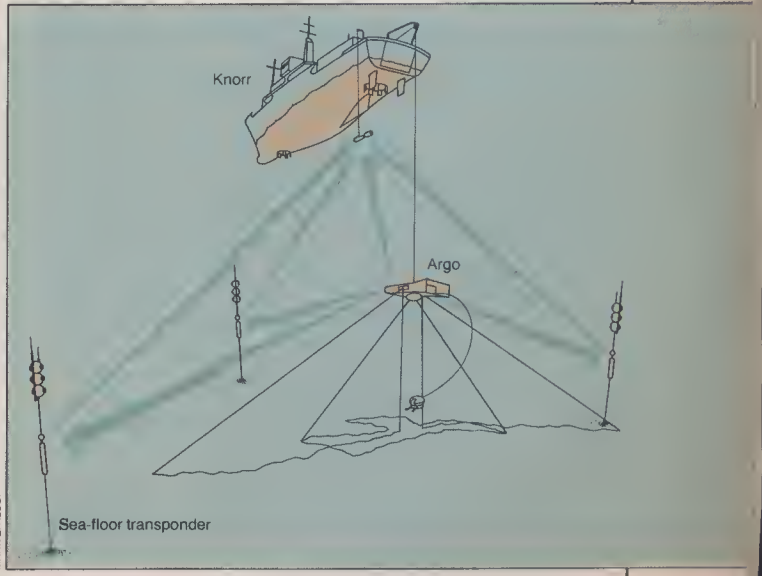
Before finding the needle, SeaSpace must first find the right haystack, since the huge data set they use for their studies is only a small subset of the total amount of oceanographic data gathered by satellites. That, in turn, is only a minute sampling of the world's vast ocean surface. Choosing the right data to analyze, therefore, can be as important as the analysis itself.

Here again, SeaSpace relies on the graphics capabilities of its computer system. By tracking the orbits of the environmental satellites that supply data, SeaSpace determines which ocean surface the satellites will sample, and then decides what portion of that area to study.

After using graphics to select the raw data and to assist in analyzing those data, SeaSpace oceanographers use personal computer–generated pictures to explain the findings of their studies to others. "Ultimately, you have to plot your data out in a fashion that is understandable to other people," says Van Woert. "That's why graphics is such an important part of our work." □ ***—Bob Hirshon***

Homing in on the Titanic

On September 1, a team of scientists from the Woods Hole Oceanographic Institution (Woods Hole, Mass.) and the French Institute for Research and Exploitation of the Sea (Paris) announced that it had found the wreckage of the "unsinkable" *Titanic* 13,000 feet below the surface of the North Atlantic. The key tool used to find the ship, whose precise



Vessels triangulate position with transponders.

location had remained a mystery for 73 years, was a towed undersea observation platform—the *Argo*—that is navigated with the help of a personal computer.

The *Titanic* discovery, which came during the *Argo*'s first field test, was an outgrowth of the Woods Hole group's larger project: using the robotic platform to map the Mid-Ocean Ridge. This undersea mountain range, the earth's largest geological feature, snakes along for nearly 45,000 miles through all the major ocean basins and covers 23% of the world's surface. Within a year, the *Argo* should be joined by another, smaller submersible, the *Jason*. Unlike the *Argo*, which relies on an IBM PC/AT only for getting navigational fixes, the *Jason* will be completely controlled by personal computers.

The *Argo* is one of a new generation of unmanned undersea probes that can descend to depths as great as 20,000 feet. (Manned submersibles, in contrast, are safe down to depths of only about 12,000 feet.) Automobile-sized and weighing about 4000 pounds, the *Argo* is towed by a winch-driven steel-armored coaxial cable. The probe is maneuvered by winding or unwinding the cable and by moving the surface ship, the 245-foot *Knorr*. The ship and the *Argo* are precisely positioned with the aid of transponders placed on the ocean floor in a known pattern, which send signals received from both vessels back to sensors on the ship. These signals travel directly to the PC, which uses custom-written software to calculate the vessels' positions on the basis of signal transit time. Separate microprocessors assist in the operation of *Argo*'s television cameras, still cameras, and side-scanning sonar.

Meanwhile, back on shore, engineers Dana Yoerger and James Newman of Woods Hole are developing the *Jason*, a smaller submersible that will be carried on the *Argo*. When the *Argo*'s cameras spot an interesting sea-floor feature, the 1000-pound *Jason* will investigate it up close.

The *Jason* has thrusters for independent maneuvering, dual color-television cameras (for 3-D perspective), and manipulator arms that can be used to obtain samples from the ocean floor or from objects such as the *Titanic*. Basic to the operation of the *Jason*, says Newman, is real-time control of all its movements by the PC/AT, which will also be used to collect data from on-board sensors.

While it is the *Titanic* discovery that has put the group in the news, its main goals are still to map the sea floor and to perform biological and chemical research along the ridge. The mapping should reveal many mineral resources, says Robert D. Ballard, head of the institution's Deep Submergence Laboratory, and should assist the Navy in a variety of applications. □ ***—Thomas H. Maugh II***

MANUFACTURING

A maintenance expert that never sleeps

Technicians at Texas Instruments' integrated circuit processing facility in Sherman, Tex., have the services of a maintenance expert around the clock and on a moment's notice. The expert is a PC–based system called the Intelligent Machine Prognosticator (IMP), and its field of expertise is the maintenance of an epitaxial reactor—a machine used by TI to grow additional layers of silicon on silicon wafers.

Before the installation of the IMP last February, keeping the complex epitaxial reactor operating was no small challenge for the Sherman facility, says Edward Clancy, equipment engineering section manager. For example, its self-diagnostic system can isolate only a few of the potential causes of failure, and its repair manual is largely limited to general maintenance procedures.

As a result, TI frequently had to call in the machine vendor's field-service staff. Only two of them were versed in the reactor's maintenance, however, and they would respond only during the day. This meant that if a breakdown occurred at the end of a day shift, TI technicians had to wait until the next morning for assistance.

The PC-based "expert system," by contrast, is available for consultation 24 hours a day. It sits on a roll-around cart next to the epitaxial reactor within easy reach of the maintenance technician. As a result, says Clancy, the mean time to repair the reactor has decreased by 36%.

The IMP runs on a TI personal computer that has 768 kilobytes of memory, a 10-megabyte hard disk, and an 8087 floating-point coprocessor chip. The total software occupies about 2 megabytes of memory. And even though it runs on a personal computer, "you do not spend a lot of time waiting for the machine," says Katherine Hunter, the TI software engineer who developed the IMP.

In a consultation the IMP system functions much like the human field-service engineers on whom it is modeled. It engages the technician on duty in a question-and-answer dialogue designed to elicit symptoms associated with a malfunction. The system then uses this information to arrive at a diagnosis and recommend a repair procedure. A consultation can take as little as a minute, says Hunter.

To diagnose a problem, the IMP first hypothesizes a cause. It then tries to verify the hypothesis by reasoning backwards to find symptoms associated with that problem, employing a "knowledge base" of inference rules of the form "IF symptom X and symptom Y and symptom Z THEN cause is A." If the symptoms do not confirm the original hypothesis, the IMP selects another, and the process continues until the problem is solved or all hypotheses have been exhausted. Once it has diagnosed the cause of a malfunction, the IMP then searches its knowledge base for repair rules of the form "IF the cause is A THEN recommend repair procedure F."

To build the IMP, Hunter used an expert system development tool—the Personal Consultant—developed by another division of TI. The Personal Consultant is a general-purpose expert system that can be customized by adding a knowledge base for a specific application. Hunter created the IMP by expanding the Personal Consultant to include rules for diagnosing the epitaxial reactor.

The IMP's rules were developed by consulting the reactor's manuals and a team of experts that included a TI process engineer, an equipment engineer, a vendor field-service engineer, and a TI technician. This process wasn't always easy. For one thing, the manual contained errors. Also, "it was difficult for all of us to begin to think in terms of IF-THEN rules," says Hunter, and the experts often disagreed on the best course of action under particular circumstances. "Technicians like to do things their own way," says Clancy, noting that one offshoot of development of the expert system was a standardization of repair procedures.

Despite these difficulties, development went quickly. The Sherman plant started work on the IMP in October 1984. A prototype of the system was installed at the facility in February. By late May, the prototype knowledge base contained about 1000 rules for diagnosing some 296 malfunctions on the basis of 50 different symptoms.

Although the IMP approaches the performance of a human expert, it can handle only problems previously incorporated into its knowledge base. But Clancy estimates that this covers about 85–95% of the problems that can occur, and when new problems are encountered, additional diagnostic rules and repair procedures can be added. "A system like this is never really finished," says Clancy.

TI plans to enhance the system so that it will maintain a record of the malfunctions it diagnoses. This would allow a determination of which problems are most likely to occur, and would thereby speed the diagnostic process. The company also plans to develop PC-based repair experts for some of its other integrated-circuit manufacturing equipment.

The reaction of TI technicians to the expert system has generally been good. "When it was first installed, there was some suspicion on the part of the technicians that the system was designed to replace them," says Clancy. But since then, "they have learned that it is nothing more than an aid." □ ***—Paul Kinnucan***

JAMEY STILLINGS

Webster's laser cutter, fed coordinates by a PC, achieves 1/500-inch accuracy.

Machine shop stays on cutting edge

Companies are sometimes happy to have to turn away customers. But Webster Tool & Die (Webster, N.Y.) was passing up business for the wrong reason: Its cutting machines weren't fast enough to handle complex precision prototyping work. To stem the flow of jobs to competitors, the machine shop purchased a $400,000 Laserdyne laser cutter that slices through sheet steel at 500 inches per minute with an accuracy of 1/500 of an inch. But the laser solved only half the problem; operators spent up to two days calculating cutting coordinates for parts that the laser could cut in minutes. That's where a personal computer came in.

On advice from a consultant, Webster added a 256K-byte IBM PC to its laser cutter. Numerical control software from Comprep (Orange, Cal.) completed the system. Now the PC calculates the cutting geometry and loads the information into the laser control, chopping the time from blueprint to complex finished part from several days to a few hours.

The company starts with a "flat blank layout," a representation of the cut part (before any necessary bending) that is derived from the customer's blueprint. Then the laser operator inputs blueprint coordinates, choosing options and answering questions posed by the menu-type PC software. A point can be input in any of six ways—as *x-y* coordinates, as a distance from an origin and an angle, or as the intersection of two lines, for example—and a circle can be defined in any of 12 ways. An upgraded version of the software now under development will allow users to draw computer-graphic pictures of the parts, from which the necessary coordinates can be obtained. Regardless of the format in which the data are entered, however, the software must eventually transform them for use by the laser's numerical control system, which accepts only *x-y* coordinates for points and a single definition for a circle.

In the current version, the software accepts up to 99 specifications for points, lines, and circles, calculates the corresponding *x-y* coordinates, and draws a picture of the part. After any required editing and additional processing, the data file is sent from the PC to the laser's numerical control. The laser does the cutting off-line from the PC, leaving the computer free for other calculations.

Allen Schoonmaker, the primary user of the PC-laser system at Webster, says it took only two days to learn the basics of the software, despite having no computer experience. Schoonmaker thinks his title, laser programmer, is misleading: "It's not programming," he explains, "it's just answering questions." The advantages of the system however, are indisputable. The PC software saves up to 14 hours of calculator work on a difficult job; at a standard charge of $50 an hour for an operator's time, that amounts to $700 savings. Webster can use such savings to widen profit margins or, more important, to bid competitively on jobs that it once would have had to pass up. The company is now working on parts ranging from a tiny battery contact for a Kodak camera to three-foot-long panels for an optical comparator. The design for one recent part incorporated over 2000 circles; plotting the cuts by calculator would have made the job unprofitable. □ ***—David H. Freedman***

Engine-part testing picks up speed

Small components can play big roles in the trouble-free operation of diesel motors. Such is the case with a bimetallic disk produced by Schwitzer (Indianapolis), a manufacturer of engine components. When an engine heats to a certain temperature, the disk—consisting of two types of metal melded together—snaps from a convex to a concave shape. This action opens a valve, allowing hydraulic fluid to push a rotor blade, activating the engine's fan. When the temperature drops, the dish snaps back and the fan switches off.

To speed the production of the bimetallic disks at its plant, Schwitzer employs an Apple IIe computer as the brain of a semi-automated testing process. Before the personal computer was harnessed for this operation, it took technicians at least five times as long to perform the same task, estimates Michael Bennett, manager of cooling systems development.

In a typical test procedure, the disk is fed by an operator into a testing apparatus. The core of the test stand is immersed in a water bath heated to a precise temperature, while a hydraulic system applies gradually increasing pressure until the disk snaps to a concave shape. Then the pressure is gradually relaxed until the part snaps back. Precision Controls (Ann Arbor, Mich.), the engine manufacturer that uses the disks, requires that they snap and reset within narrow ranges of temperature and pressure, so any parts that deform outside these ranges must be reworked.

When a disk drops into the test stand, special sensors wired to the computer note its presence and start a sequence of events. Computer-controlled actuators position and seal the disk before pressurization. Then a motor, also directed by the computer, applies hydraulic pressure on the part in steady increments. Once the disk snaps, sensors in the test stand signal the computer, which records the pressure reading fed to it by a sensor in the apparatus. When the part snaps back, sensors again activate the computer to record the pressure at that point. If the recorded pressures are within preset limits, the computer signals the operator that the part is good and ejects it from the test stand. If they are not, the computer flags the part for reworking.

Operators must enter such things as disk part number, how far the pressure will be "ramped" up and down, and the desired pressure limits for deformation and recovery of the disk shape. But all the other test procedures are done automatically by the computer. As a result, says Bennett, "you remove the possibility of error in readings, the process is more repeatable, and you can run it without a highly trained operator."

Because the amounts of data input and output in this process exceed the normal capacity of the Apple IIe, the Schwitzer staff has added four controller boards—supplied by Systems Manufacturing Technology (San Marcos, Cal.)—that fit into slots both in the computer and in a custom-built circuitry enclosure. One board allows the computer to send and receive data from as many as 128 remote locations via a coaxial cable. Another converts analog signals from sensors into the digital form computers can process. The other two boards allow the computer to control various power switches connected to mechanical parts in the test stand.

The test software, developed in-house, allows operators to set the parameters of a test and follow it on screen. But very little supervision of the test stand is actually needed after the initial settings are keyed in. "The basic use of the system," says Bennett, "is to put a part in on one end, take it out on the other end, and know that it's good." □ ***—Gordon Graff***

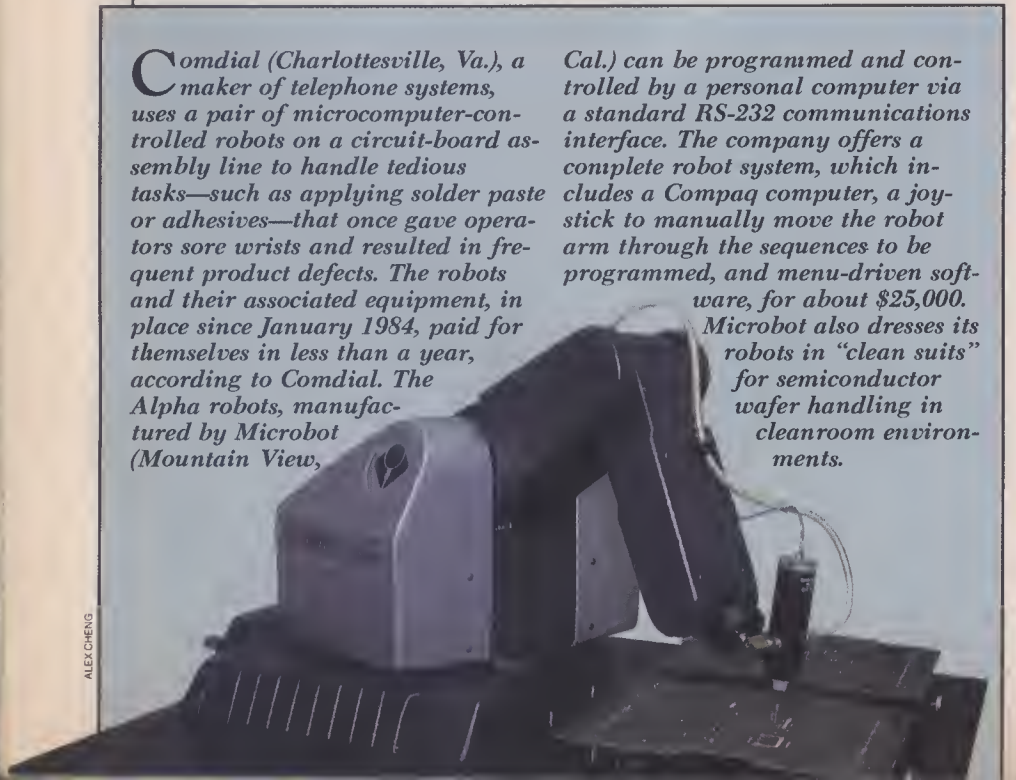
Voice system cuts inventory errors

Refrigerated loading docks are great for preserving food, but they have a chilling effect on the accurate taking of inventory. At the Carra Donna Provision Co. (Boston), figures scribbled onto paper by frozen fingers were later entered manually into the company computer—an inefficient and error-prone process. To improve the situation, Carra Donna added a voice recognition circuit board to its IBM PC/XT, permitting workers to enter stock information verbally.

The company chose a $2500 Votan VPC-2000 voice recognition system, an expansion card for the IBM PC that can also provide voice synthesis and connect the computer to a telephone. This system saves the company as much as $18,000 a year—the cost of another employee—"and it doesn't ask for days off or raises," says Sandra Wyman, data processing manager for Cara Donna.

The Votan-equipped PC/XT is installed behind a glass window next to the loading dock. The stock handler communicates with the system via a microphone on a headset, an arrangement that leaves both hands free. As a forklift driver unloads crate after crate of, say, salamis or cheeses, the handler speaks their weights and serial numbers into the system. Spoken

Comdial (Charlottesville, Va.), a maker of telephone systems, uses a pair of microcomputer-controlled robots on a circuit-board assembly line to handle tedious tasks—such as applying solder paste or adhesives—that once gave operators sore wrists and resulted in frequent product defects. The robots and their associated equipment, in place since January 1984, paid for themselves in less than a year, according to Comdial. The Alpha robots, manufactured by Microbot (Mountain View, Cal.) can be programmed and controlled by a personal computer via a standard RS-232 communications interface. The company offers a complete robot system, which includes a Compaq computer, a joystick to manually move the robot arm through the sequences to be programmed, and menu-driven software, for about $25,000. Microbot also dresses its robots in "clean suits" for semiconductor wafer handling in cleanroom environments.



ALEX CHENG

numbers appear on the computer's color video screen—visible through the glass window—allowing him to verify the data's accuracy. If he makes a mistake, if someone else on the dock speaks, or if the computer fails to recognize a word, the handler can tell the computer to back up one or more entries. If he needs to speak to a coworker, he can tell the unit to stop listening.

The system's vocabulary consists of the numbers 0 through 10, in addition to several basic editing and special function commands. According to Cara Donna, the voice recognizer has stopped transposition errors, the tendency to write down numbers out of sequence. The Votan board is "transparent" to the host computer in that it requires no changes in the other programs Cara Donna runs. What's more, says Wyman, "the system operates at a level where an average person can use it."

Following its success with the loading dock application, the company has also begun using the voice recognizer/synthesizer as a telephone ordering system, permitting customers (mainly grocery stores and delis) to phone in orders around the clock. The integrated system can handle up to three callers at once and can respond with its synthesizer in a humanlike voice. The first time customers call, they must participate in a short "training session." This allows the voice recognizer to learn how the user speaks, and it gives the customer time to get used to the sound of the synthesizer. The process, which entails speaking a predetermined vocabulary into the telephone, takes approximately 20 minutes. Once the session is completed and a password has been assigned, the grocer or restaurant owner can begin using the system to order stock. "The main idea," says Wyman, "is that the customer, and not one of our employees, is doing the work." □

—Joseph J. Lazzaro

PROFESSIONAL

Brokerage house offers clients more choices

As a result of the intense competition in today's financial services industry, many of the smaller brokerage houses are overshadowed by the Merrill Lynches and Dean Witter Reynoldses of the world. Even leading regional firms like Raymond James & Associates—with more than 30 offices in Florida, Tennessee, and Georgia—are hard pressed to keep up. But Raymond James (based in St. Petersburg, Fla.) has found one way to stay in the game: providing its clients, many of them wealthy Sun Belt retirees, with personalized computer-based services.

A year and a half ago, Raymond James began buying personal computers and linking them to the larger machines from Tandem Computers that the firm uses to execute orders to buy and sell. So far, the company has about as many PCs as offices, having spent $125,000 to buy an assortment of IBM PCs, AT&T PC/6300s, Corona PCs, ITT Xtras, and Panasonic Senior Partners (all of which are IBM PC–compatible). "The ultimate goal is to have an intelligent terminal on every broker's desk," says Ken Ziesenheim, VP of financial planning. He believes the PCs are especially well suited to investment counseling and long-term planning, allowing brokers to perform sophisticated "what if?" calculations on individual customer accounts.

Ziesenheim himself uses one of the PCs to map out investment strategies for clients he advises about financial and estate planning. Tax planning software can quickly provide "a person in a particular cash flow or tax situation with ten different alternatives," he says. Financial analysis programs such as Lotus 1-2-3 can also instantly calculate how each investment may diversify someone's portfolio. Members of the firm who deal with corporate clients use the PCs to analyze how growing young companies can raise money and to determine appropriate stock prices for initial public offerings. And for all Raymond James's customers, the machines help meet the constant demand for information that is a hallmark of the brokerage business. Such a flow "instills client loyalty," says Ziesenheim. "The more information—whether it's good or bad—the happier the client is."

Within the firm, the PCs also serve as management aids to senior executives, helping them track individual members of the sales staff and monitor overall company performance. Financial analysis programs make it easier to break out the balance sheets of individual departments and to chart the revenues from different services the firm offers. Impressed with the results of its experiments, the firm plans to increase the number of PCs at the staff's disposal, reports Ziesenheim. "Everybody's just beginning to tap the machine's potential." □

—Tim Smart

A legal aide with a great head for facts

The Atlanta law firm of Harkleroad and Hardy is convinced that its 16 personal computers save the firm time and keep its payroll lean. Since the mid-1970s, when the partners bought their first computer system, they have gradually let it take over tasks that range from the drafting of contracts, briefs, and other legal documents to the writing of checks for office expenses. "We use computers in our financial accounting department, in keeping up with client lists, and for litigation support," says senior partner Don Harkleroad, as well as for financial analysis in the tax and security cases that are the firm's specialty.

In the past few years, Harkleroad and Hardy has spent $80,000 to update its old system, which was built around an IBM minicomputer. Today the firm's 35 employees work with a more versatile array of equipment, including an IBM PC/AT, 12 IBM Displaywriters (personal computers customized for word processing), a Digital Equipment Corp. Rainbow VT-200, and two Hewlett-Packard 111 briefcase-size portables. The computers not only make it far simpler to generate contracts and other documents that contain standard "boilerplate" passages but also help organize the reams of research material that must often be gathered for cases. "In litigation, particularly cases that involve many parties and complex proofs," says Harkleroad, "we enter an awful lot of information," knowing that the computer can quickly fish relevant facts out of its memory when they're needed. He especially appreciates the word-processing system's "search" function, which instantly locates and highlights key words or phrases in lengthy legal documents.

The firm also uses its personal computers to send and receive electronic mail, which it increasingly relies on to communicate with clients who own computers and to link the senior partners' portables with the office when

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they're working at home or on the road. Harkleroad says he travels with the Hewlett-Packard "all the time," using it aboard planes and in hotel rooms to keep in close contact with the firm. He also reports that he no longer lugs a briefcase home any more, preferring to take the portable instead.

The American Bar Association estimates that 80% of all lawyers use computers to some extent, although usually just to generate routine documents. The attorneys at Harkleroad and Hardy, who say that their computer expertise is self-taught, are therefore ahead of the pack. In fact, Harkleroad reports that they do an increasing amount of what he terms "computer law"—drafting licensing agreements for software companies and devising ways to protect their products from copyright infringements. The firm also advises some of its less technically oriented clients about appropriate systems for their businesses. Thus, at the same time micros are streamlining the firm's operations, they are actually expanding its practice. □ ***—Elizabeth Willson***

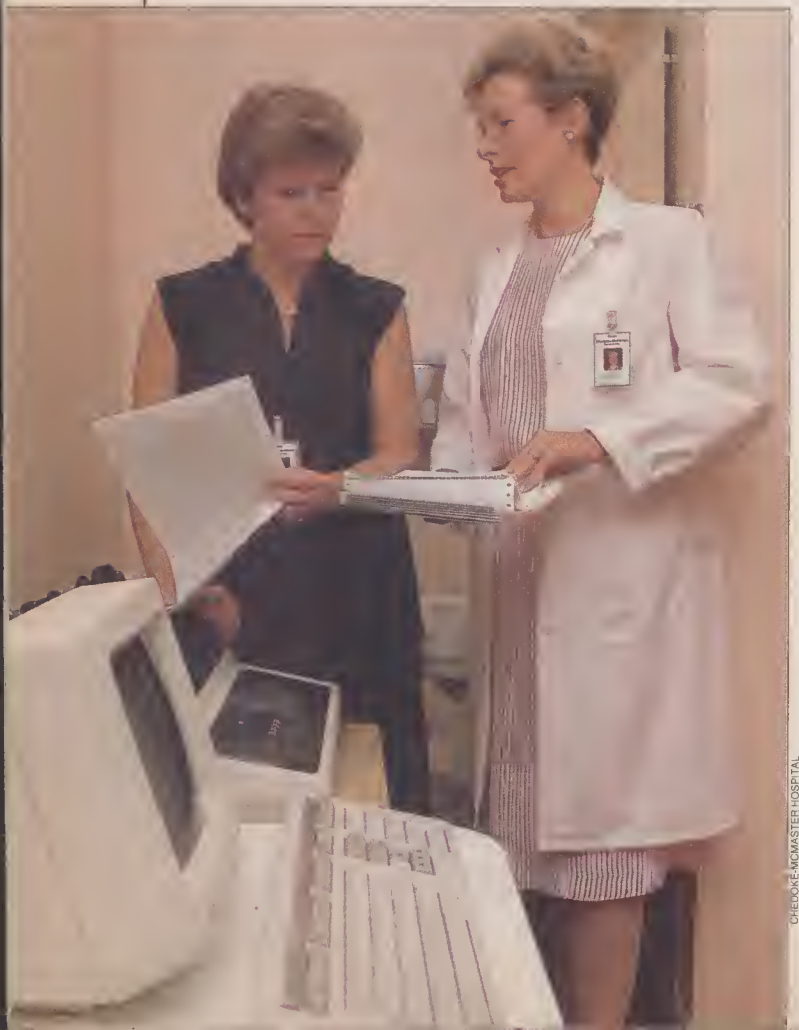
Hospital keeps patient records orderly

How does a major hospital keep track of eight different study programs, 100 staff members, and 3000 outpatients who make 60,000 visits a year? At McMaster University Hospital (Hamilton, Ont.), the answer is a database system called Clinical Data Manager (CDM), developed in 1976 at the Harvard School of Public Health. McMaster acquired the system in early 1983 from Clinical Data in Boston, which specializes in healthcare electronics and information management.

"We'd previously used the university mainframe for storing and analyzing patient data," says McMaster epidemiologist Peter Pettingill, "but it was a very slow way of retrieving information." Another drawback, he says, is that the system could be used only by experienced programmers.

By contrast, the CDM database—essentially an electronic file cabinet containing special information on any patient, physician, or subject the user wants to follow—is designed so the hospital staff can set up files themselves simply by answering a series of questions in plain English. Patient files, for example, might be arranged to contain such parameters as age, weight, surgical history, and special risk factors.

McMaster University Hospital's database system tracks patients' progress and maintains physicians' files.



CHEDOKE-MCMASTER HOSPITAL

Once the database is defined, says Pettingill, data are entered or retrieved in just a few seconds. The system also contains several subroutines for evaluating the accuracy of new data against a series of internal checks. Blood pressures are compared with a previously defined range of values, for example; if a reading is entered that is outside the range, an error message prompts the user to recheck the entry. Moreover, any entry can be called up and combined with other entries—a feature helpful for designing and initiating new research programs.

"Suppose we want to do a study, and need 75 patients within a certain age group who have been diagnosed with such and such a condition," says Pettingill. "This system lets us go through all our records in just a few minutes, then prints a list of potential candidates." Such data can even be used to generate patient query letters through an optional word-processing interface. And once the study has been completed, CDM's built-in statistical program can analyze results.

The system is being installed on IBM PC/ATs at various locations throughout the multibuilding complex, to be used primarily by clinical program managers and clerical staff. (The hospital also maintains a larger version of CDM, using a DEC minicomputer.) For now, the program is used primarily for tracking patient progress and maintaining physician files. But Pettingill is convinced that McMaster has only begun to explore the full potential of the program. "It's a lot like playing the piano," he says. "You can satisfy yourself with a few simple tunes, or you can work your way up to the concert hall."

CDM has also provided an unexpected benefit. By allowing program managers to pull complex reports together quickly, it has become a valuable tool for keeping funders informed about the hospital's programs (an activity that often consumes much administrative time). "Even if we used CDM only for this purpose," says Pettingill, "it would probably pay for itself after a year." □ ***—H. Garrett DeYoung***

Architects try a new blueprint for success

The resumes Bill German receives from aspiring young architects these days list more than just design experience and educational background. Increasingly, they also mention the kinds of computer systems that applicants are accustomed to using. To attract and keep such talent was one reason McCleary/German Associates—a small Houston architectural firm that specializes in designing bank buildings—plunked down $15,000 last April for its first computer system: an IBM PC/AT and architec-

JOHN GROSSMAN

With architectural design software from Mega CADD, a McCleary/German building plan (left) automatically accommodates changes in a particular office (center and right).

tural design software from Mega-CADD (Seattle). Another incentive for the purchase was keeping up with the competition. "All our larger competitors were doing it," says German, a partner in the 45-year-old, 20-employee firm. "How can you ride a horse when everyone else has cars?"

Architects at McCleary/German still draw their initial plans by hand, but they now convert these drawings to computer models. By sliding a computer "mouse" across a plan, they enter various points in a drawing, which the system then connects to complete the model. Common objects such as chairs, desks, windows—even whole wings of buildings—can be stored in the computer's disk memory and called up later.

Although the design software can't perform tasks as complex as solids modeling—a feature of high-powered mechanical engineering programs—the small-scale system still greatly increases the firm's productivity, says German. If a client wants to modify a drawing by, say, moving a wall, it can be deleted electronically and quickly drawn in elsewhere. The drawing can be manipulated in varying scale—zooming in on an elevator, or stepping back to take in landscaping. The system will remove "hidden lines"—those making up the back side of a desk, for instance, for a room's front view—and can even produce a shaded three-dimensional drawing.

The PC also comes in handy after a design is finished. "It used to take two to three days to calculate gross rentable square footage of a building," says German. Now, from a model's dimensions and scale, the computer can precisely calculate area "in five minutes." Of course, he adds, the data fed in must be precise: "The computer doesn't recognize guesswork."

The firm's ability to make quick changes and offer an array of options, says German, has already brought in new business. For example, a Houston landlord recently commissioned a series of alternative layouts for a bank on one floor of an oddly shaped building. He can now show prospective tenants laser-printed drawings of five possible designs.

Despite its numerous advantages, the computer has remained a mystery to some members of the firm's staff. "They're going to ride horses for a while," says German. "But several of us jumped right in and spent every available hour learning how to use it." □ ***—Dan Beucke***

EDUCATION

Videodisc trains service reps

Like many service support representatives, those at Xerox must field phoned-in customer complaints, record the problems accurately, and relay appropriate information to field service technicians. Unlike most support reps elsewhere, however, they are now being trained with an automated system that combines the processing power of personal computers with the audiovisual capabilities of videodiscs.

To teach the personal skills required, as well as the technical, Xerox turned to interactive laser videodiscs. Instead of passively reading textual information, the student can actually see how experts do the job. The student can easily loop back through the program to review any lesson.

In a typical Xerox program vignette, the student sees a service rep sitting in front of a computer terminal and talking to a customer. The student can hear both sides of the conversation, watch data being entered and displayed, and observe how the rep's responses vary according to the urgency of the problem and the nature of the call. One of the telephone skills imparted, for example, is how to deal with a customer who is taking too much time to explain the difficulty.

Xerox's video production department is developing courseware modules using course-authoring software called Authority, from Interactive Training Systems (ITS) in Cambridge, Mass. According to Jim Ozipko, manager of training development at Xerox National Service (Rochester, N.Y.), Authority makes it easy to create multimedia courseware—for example, combining computer-generated text with a video scene and adding supporting audio—and helps developers build pathways to different parts of the courseware in anticipation of student questions. ITS licenses its Authority software for a fee of $9500 to companies such as Xerox, which use it to produce courses for internal use.

The Xerox training system, also obtained from ITS, includes an IBM PC (which controls the pace of program delivery, generates appropriate text and graphics, and tracks student performance), a Hitachi videodisc player (some Pioneer and Sony machines are also used), a PC controller board, and a Zenith high-resolution color monitor. The complete system costs $9950.

Xerox began using the videodisc training systems just last April, but the early results have been encouraging, says Ozipko. "Training is now consistent in different locations, and easy to administer. On the whole, we are accomplishing more training in less time." □ ***—Dennis Livingston***

℞ for lower training costs

Houston-based Owen Healthcare manages pharmacies for 130 hospitals in 29 states. By providing everything from medications to lighting fixtures, and by having its pharmacists promote generic drugs, Owen helps cut patient costs and boost pharmacy profits. Now the firm has come up with a way of reducing one of its own costs: pharmacist training. Owen is replacing a $1500-per-site in-person training program in pharmacy accounting and related procedures with computer-based courses.

The computer-based training (CBT) program is a pet project of Joel Farb, director of research and special projects. A self-styled "radical behavioralist" with a degree in developmental psychology, Farb puts his faith in self-paced instruction—especially when provided by a computer that can ask questions and give feedback. Armed with a $495 CBT software development package called "The Author Plus" from Raptor Systems (Stillwater, Minn.), Farb developed the courses to run on Owen's Sperry personal computers.

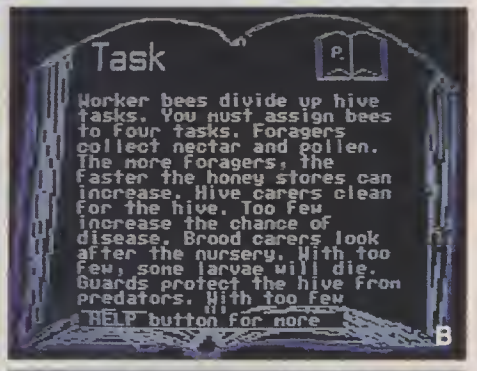
Incorporating textual information and simple graphics followed by multiple-choice questions, the accounting course teaches Owen's elaborate cost-tracking procedures. Pharmacists learn, for example, to check every medication listed on a patient bill against the pharmacy's invoice, the nursing records, and the patient's charts. A companion course teaches pharmacists and support personnel how to keep up with volatile drug prices, which may shift monthly. A third course teaches employees in the home office how to use the company's computerized phone system. Courses are split into a maximum of 10 one-hour sessions, each providing the opportunity to examine quiz results and review those areas not mastered the first time around.

Owen's CBT program is still in a testing stage, but Farb expects the results to equal or better those of in-person training—and at a far lower cost. He also sees advantages over noncomputer forms of self-paced training. Written manuals don't demand the student's attention and don't provide immediate feedback; traditional audiovisual presentations aren't interactive enough to make the lessons stick; and interactive laser videodisc systems are too expensive, at least for a company with small, dispersed groups of personnel.

Of course, PCs aren't all that cheap either. But almost a quarter of Owen's pharmacies already have PCs to help run operations, and that proportion is expected to grow. Course development represents the major cost of CBT programs. At a ratio of about 100 hours of development for each hour of finished lessons, salary costs can top $10,000 for a 10-hour course. But Farb points out that costs for traditional course development can approach that figure. And because CBT should prove more effective than other methods, asserts Farb, the company will also save on "the very real costs associated with accounting errors." □

—David H. Freedman

Children who play with bees normally get little out of the experience other than a painful lesson about how the bee's stinger got its name. But scientists have long been fascinated by the activities of these social insects, and a new software package called "The Honey Factory" is designed to instill some of the scientists' knowledge and wonder in grade-school children. "The Honey Factory" is set up as a game of survival, with students playing the roles of bees who must forage for food, avoid predators such as birds and spiders, guard and expand the colony, and swarm to start new hives. There are four increasingly difficult levels of play (A). After the first level, students must divide the bees into groups that perform specific tasks (B). Scouts, for example, explore the area around the hive searching for food sources (C), and must be aware of the weather (bees don't fly in the rain), the time (they must return to the hive by 6 PM), and their own supply of "fuel" (the energy they gain by drinking nectar). When a scout returns to the hive, the student fills in a "Tell Chart" to give information such as which type of flower was found (D) and how many foragers are required to collect the nectar and pollen. The $49.95 software, created by Keron Productions (New York) and sold by Holt, Rinehart and Winston (New York), runs on Apple personal computers.



PHOTO/ILLUSTRATION

Computerizing the campus

Until a few years ago, most of the computing at Carnegie-Mellon University (Pittsburgh) was done on terminals connected to campus mainframes. Now, these "dumb" terminals have all but been replaced by personal computers, which can serve as independent processors as well as terminals that can access mainframe information. "Few students graduate from here without being exposed extensively to the computer as a working tool," says John Patrick Crecine, CMU's se-

BILL REDIC

Carnegie-Mellon students work on Macintoshes at a library computing center.

nior vice-president of academic affairs. "It's just as basic to their classroom activities as the library."

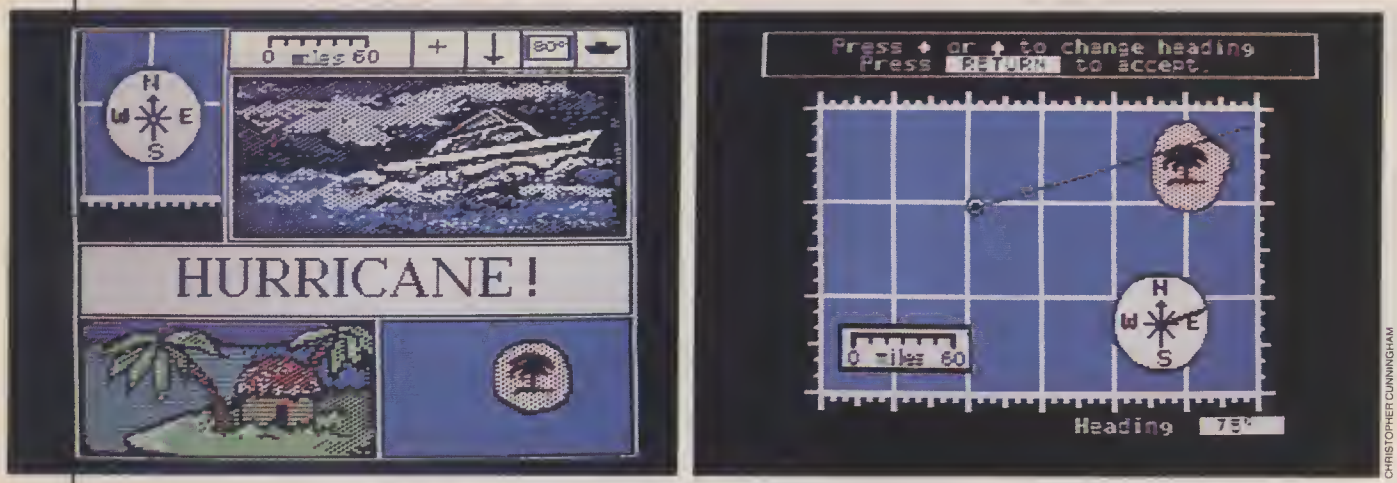
CMU counts at least 4200 personal computers in use among its 4200 undergraduates, 1200 graduate students, and 500 faculty members. Although students are not required to buy their own computers, up to half the student body has done so, taking advantage of the 30–55% discounts that CMU has arranged with various manufacturers. According to Crecine, some 2000 of the personal computers are IBM PCs, PC/XTs and PC/ATs, and another 2000 are Apple Macintoshes. The remaining 200 micros are about equally divided between Digital Equipment and Hewlett-Packard machines. About 70% of the IBMs have been obtained either through donation from the company for research purposes, or through institutional purchases by CMU for use by faculty and by students in computer centers. The remaining 30% of the IBMs have been individually purchased. These percentages are almost exactly reversed for the Macintosh.

Most students use personal computers to enhance productivity, through such applications as word processing, electronic communications, and data manipulation. Computers also find a wide range of uses as educational tools in many classrooms. "Every department has at least one significant software project under way, with fine arts and liberal arts courses providing many of the most interesting micro applications," says Crecine.

Students in the introductory psychology course, for example, can use a computer to duplicate some classic experiments in perception and memory. In one experiment the computer displays visual patterns at predetermined intervals and then tests student subjects on their recall. Examining test results for the classroom, the students can draw conclusions and check them against those of the original experiment. In an application that makes use of the computer's ability to sort through data, students studying the industrialization of American society can trace changes in the social status of immigrants by analyzing information contained in the personnel records of a now-defunct Pittsburgh steel mill. And in a world history class, students build hypotheses about the causes of unrest leading to the French Revolution by examining information coded from the Notebooks of Grievances.

In these applications the student is exposed to the kinds of data used by professionals in each field and the ways in which they might draw out and test hypotheses. This can be "a more helpful way of getting across concepts than a textbook," says John Stuckey, director of computing at CMU's College of Humanities and Social Science—though he also stresses that "the computer does not dominate the classroom."

CMU buttresses its applications with an array of resources. To ensure a minimum level of computer competency, every incoming student must take a basic computer course. This course, part of a new universitywide core curriculum, familiarizes students with nonprogramming skills such as text editing, database management, and electronic communications. A Center for the Design of Educational Computing helps faculty to develop software and serves as the home base for a program-sharing consortium of about 15 universities. And



In part of the educational package "Voyage of the Mimi," a hurricane forces young navigators to chart a course to safety.

an Information Technology Center pursues research under a $20 million, three-year program sponsored by IBM to help devise the software, file systems, protocols, and user interface for an advanced "scholar's workstation" being developed by the company. □

—Dennis Livingston

Grade-schoolers embark on science "voyage"

Innovative software for microcomputers is helping education take on new dimensions in the grade-school classroom. One prominent example is a multimedia package that tracks the adventures of a teenage crew sailing aboard the ketch *Mimi* in search of humpback whales. "Voyage of the Mimi"—a $1000 package of 13 videocassettes, four microcomputer programs, and associated print materials from Bank Street College (New York)—lets students explore new methods of scientific research on whales while learning navigation, ecology, and computing.

Developed under a grant from the U.S. Department of Education, "Voyage of the Mimi" is designed to supplement the standard school curricula for grades four, five, and six. The 13 half-hour shows each consist of a 15-minute episode in a continuing adventure drama plus a documentary "expedition" that expands on one of the episode's concepts. The four related computer programs—Maps and Navigation, Whales and their Environment, Introduction to Computing, and Ecosystems—employ computer-graphic simulations to demonstrate the scientific concepts introduced in the films and help the class explore subjects further. The software (published by Holt, Rinehart and Winston), which runs on the Apple IIc and IIe personal computers, can also be used separately from the videocassettes.

Teachers who have used the package say that its multidisciplinary approach allows for a colorful and practical way of learning. "I had kids coming in every day asking, 'Can we do "Mimi" again?' " says Yolanda Rodriguez, a math teacher in the Cambridge, Mass., school system. "The program is stimulating and practically limitless in its usefulness. The ending always comes too soon." The program demands a lot of time from teachers, she notes, but "it gets the kids excited about math, science, and technology in a way that conventional textbook instruction can't."

Mary Leonard, a home economics teacher in Arlington, Mass., reports that school administrators are also enthusiastic about the program, despite its cost. "Some want to extend it from six or eight weeks to a full year," she says. "They're seeing teachers using it to open up a world of science to children who may otherwise have shown little interest." □ ***—Alison Ix***

CONSUMER

Solar house runs itself

Jack Turner hasn't turned off his computer in four years. The Apple II+ sits in a corner utility room of his Cambridge, Mass., house, maintaining nonstop control over an innovative solar heating system. Basing its decisions on various temperature readings, the computer actuates valves and pumps to direct the flow of water among the system's main elements: rooftop collection panels, two insulated tanks of unequal size, a heat pump, and heat exchanging coils. Turner, an electrical engineer, worked with the architect and building contractor to make sure the house would accommodate this equipment and all the attendant wirings.

In normal operation, water from the large tank circulates through the 500 square feet of collectors. The solar control program, which Turner wrote in BASIC, continuously compares the temperature of the water entering and exiting the collector; as long as the exit water is warmer, the computer maintains the flow. When the indoor thermostat calls for heat, tank water is directed through the heat-exchanging coils, which sit in a constant stream of air blowing through the house ductworks.

When water in the big tank drops below the 80° F minimum temperature needed to keep the house warm, the heat pump enters the picture. The computer routes the tepid water through the refrigerator side of the heat pump and sends water from the small tank through the heating side, resulting in a heat transfer from the big tank to the small one. Because of the small tank's comparatively low thermal mass, its temperature rises appreciably, and it can be used to heat the house.

On cold, dark days when the combined efforts of the sun and the heat pump can't keep the house comfort-

able, a backup furnace kicks on. As a safeguard against computer failure, the furnace is controlled by a conventional thermostat "totally outside the computer loop," says Turner. In summertime, the solar collectors take a vacation, but the heat pump stays on. Its hot output augments the gas hot water heater, and its cold output flows to the heat exchanger to cool the house. Turner figures the total bill for heating and cooling—including gas for the furnace and electricity for the heat pump—comes to about $850 a year.

Although the solar control program normally runs nonstop, Turner can suspend it temporarily to free the computer for other tasks. When he wants to tap into an on-line database, for example, the heat pump, valves, and water pumps remain in the same operating state they were in at the time of the interruption. When Turner reloads the solar program, it automatically resumes control of the house on the basis of current temperature readings. □ ***—Herb Brody***

Rooftop solar collectors are part of a PC-controlled heating and cooling system in Jack Turner's Cambridge, Mass., home.

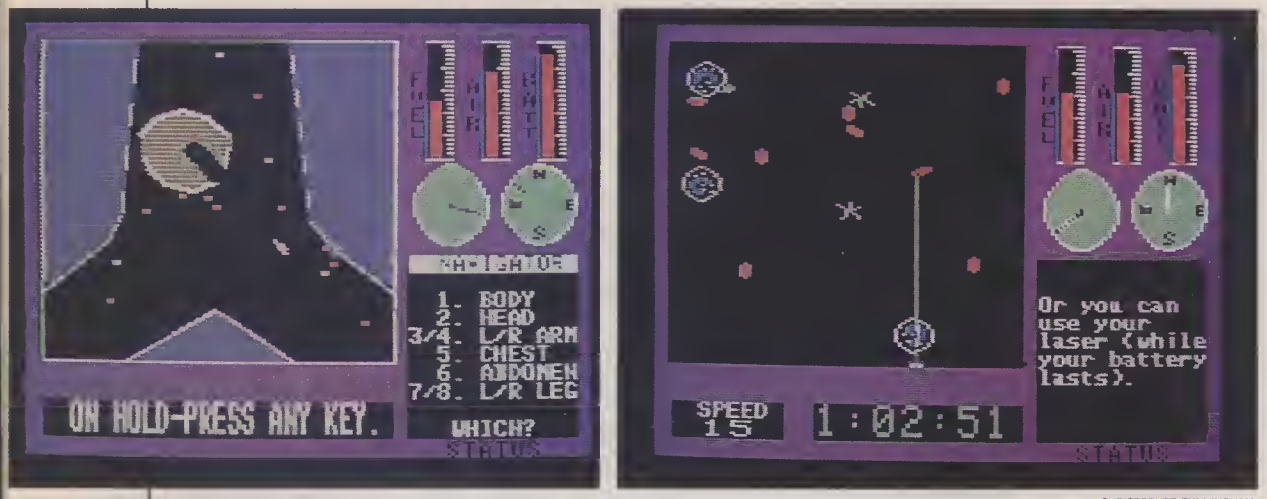
Tracking investments like a pro

When Donald Kraft of Skokie, Ill., retired four years ago, he decided it was time to take his stock portfolio more seriously. He began charting his investments with a newly purchased IBM PC and popular spreadsheet programs—first VisiCalc and later Lotus 1-2-3. Recalling the many years he pored over the back pages of the *Wall Street Journal*, Kraft says, "I don't know how I did without the PC." Today, updating his portfolio of 25 to 30 stocks takes barely a minute; Kraft connects his computer to the phone system with a Hayes 1200B modem and takes advantage of evening discount phone rates to dial up stock quotes long after the markets have closed for the day. "It costs me about 40¢ a night," he says.

Over the last four years, Kraft tried various software packages designed to assist individual investors; he found some that were "good" but none that satisfied him completely. Fortunately, he discovered that "spreadsheet programs like Lotus 1-2-3 were just ideal" for his purposes, and he devised a series of 10 portfolio programs based on 1-2-3. One program automatically issues "sell" orders when stocks reach individually predetermined prices, while another calculates his current net worth. Yet another program incorporates the Dow Jones Industrial Average and the Standard & Poor 500 index daily, so Kraft can compare his own portfolio's performance against the most common market yardsticks.

Looking back on his old method of totaling up gains and losses with pencil and paper, Kraft realizes that he "never really kept records before," discouraged by the effort needed to track a portfolio by hand. "Now," he says, "I feel I have more control."

Since buying his computer, Kraft has become active in the American Institute of Individual Investors, a Chicago-based organization that has a special group for members with com-



CHRISTOPHER CUNNINGHAM

In "Microbe: the Anatomical Adventure," players navigate arteries to save a patient and win the game.

puters. The group, which acts as a formalized grapevine for information on hardware and software, surveys members annually about their equipment and publishes a newsletter to help investors like Kraft learn the latest in computerized portfolio management. Kraft sells copies of his own investment programs to other members for $100. □ ***—Tim Smart***

Avoiding hassles by banking at home

For Kathryn Dallam, a 28-year-old secretary from the Bronx, computerized home banking was an escape route from financial chaos. "I used to bounce checks like crazy," she says. But that all changed in 1981, when she agreed to become one of 200 test customers for the pilot version of Chemical Bank's Pronto home banking service. Dallam liked the service so much that she bought an Atari 400 personal computer through the bank and is now one of 25,000 consumers who use PCs to tap into Chemical's 24-hour home banking system.

With the obvious exceptions of deposits and cash withdrawals, Dallam can conduct all her banking transactions through her computer. She has around-the-clock access to account balances and can transfer money from one account to another or pay bills electronically to 4500 participating New York merchants and companies. Her Atari also plugs her into Chemical's latest interest rates for money market funds, home mortgages, and other bank loans.

Dallam has never determined precisely how much money she saves by avoiding postage costs, check-printing fees, and bounced-check penalties, but the most precious saving, she says, has been of time. She no longer has to spend hours trying to balance her checkbook or waste her lunch hour standing in long bank lines. When she has questions concerning her accounts, she simply turns on her computer and modem, dials a phone number, and types her password and her secret account number on the computer keyboard. Inquiries sent during banking hours get an immediate reply; those sent after hours are answered the next morning.

Although most of Chemical's home-banking customers use personal computers that are more sophisticated than the Atari 400, Dallam finds her simple machine quite adequate. "Home banking has made my life a lot easier," she says. "I'd recommend it to anybody." And it's been over four years now since she bounced a check. □ ***—Elizabeth Willson***

Game pits players against killer microbes

Nearly 20 years ago, the movie *Fantastic Voyage* chronicled a fictional journey through the human body. Now the trip can be taken at home—on a video screen—with a computer game called "Microbe: the Anatomical Adventure." Developed by Synergistic Software (Renton, Wash.), "Microbe" puts the player in a race against time to save a critically ill patient; a miniature submarine must be guided through the bloodstream, with a stop at the liver (the sub's fuel station), a trip through each chamber of the heart, and a run through intricate mazes within the lungs.

What makes "Microbe" more interesting than many other games in the "obstacle course" genre is its accurate portrayal of human anatomy, says Joseph Elia, an editor at *The New England Journal of Medicine* by day and a game reviewer for *Popular Computing* magazine by night. He reports that it realistically simulates blood flow from one ventricle to another, for instance, as well as the body's responses to medical treatments.

A journey lasts 1 1/2 hours on average, and takes place under one of 1000 possible scenarios that combine life-threatening emergencies—from artery blockages to gunshot wounds—with personalized medical histories complete with allergies and chronic ailments. Players must also respond to attacks by viruses or bacteria and to major crises like heart failure. If the time pressure gets too intense, however, they can freeze the action for a rest or a quick anatomy cram session.

Elia, who plays "Microbe" on his Apple IIe, admits that a brushup on anatomy improved his own times but claims that anyone from age eight up should be able to master the game with practice. He predicts that "Microbe" will be especially popular with parents of joystick junkies and with adult players who want games to have redeeming educational value but to be fun nonetheless. □ ***—Mary Jo Foley***

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Summary:

Even the smoothest voice is discontinuous, especially in conversation. Data communications has bursts of message and periods of silence, too. Even TV has some "bursty" traits. GTE scientists are isolating silences and inserting other messages into them. This permits voice and data to coexist on the same channel at the same apparent time. The development stems from parallel research in microelectronics, silence detection, speech, voice compression and signal processing.

Without basic change, or vast growth, telephone networks will be unable to cope with the anticipated traffic of the 1990's. The proliferation of personal computers and data terminals has already placed a strain on switching and transmission facilities. It has also placed demands on networks that are much different from the original voice-communications concept, in which average time of connection was three minutes.

Today, far shorter and far longer connections abound, more subscriber lines are in demand, and there are growing needs for enhanced services and faster switching.

Out of research dating from 1979, GTE has developed a switching system that promises not only to triple present transmission capacity but also to process calls 20 times faster. The system is called Burst Switching.

The nature of speech.

Our world is full of holes. Matter is mostly empty space. Conversation is mostly silence. But, even though speech is 2/3 silence interspersed with bursts of sound from 0.1 to 1.5 seconds long, if that speech goes over a telephone line, the line is locked up for the duration.

But, with Burst Switching, we can shoehorn other messages into the silences, automatically easing the pressure on transmission facilities. Theoretically, in fact, we triple transmission capacity.

VHSIC.

Through Very High-Speed Integrated Circuits (in which we are currently researching devices with submicron feature size), we are able to make and break telephone connections at increasingly high speeds. Voice lines need be dedicated only for the very brief duration of voice bursts. At other times, channels are available for other voice messages, or for data streams which are also "bursty" in nature. In addition, video, because of its built-in redundancy, can be considered to have bursts, too.

# of silence.

Message compression.

The capacity needed to transmit speech can be made even smaller if the information that must be sent to make it recognizable can be minimized. Our scientists have reduced the 64 kb/s signals to 16 kb/s while retaining high quality.

Thus, transmission-capacity requirement is reduced by a factor of four.

We are working, as well, on techniques for compressing video signals from 90 Mb/s to 64 kb/s. This will have special relevance for such activities as video conferencing.

So transmission capability grows and switching becomes faster—and we can now envision future telephone systems able to carry billions of simultaneous calls.

The box at the right lists some of the pertinent papers GTE people have published on Burst Switching and related subjects. For any of these, you are invited to write GTE Marketing Services Center, Department TPIIB, 70 Empire Drive, West Seneca, NY 14224.

Burst Switching experimental model.

Pertinent Papers.

Burst Switching—An Introduction, IEEE Communications Magazine, November 1983.

New Switching Concept Integrates Voice and Data Bursts, PROFILE, September 1983.

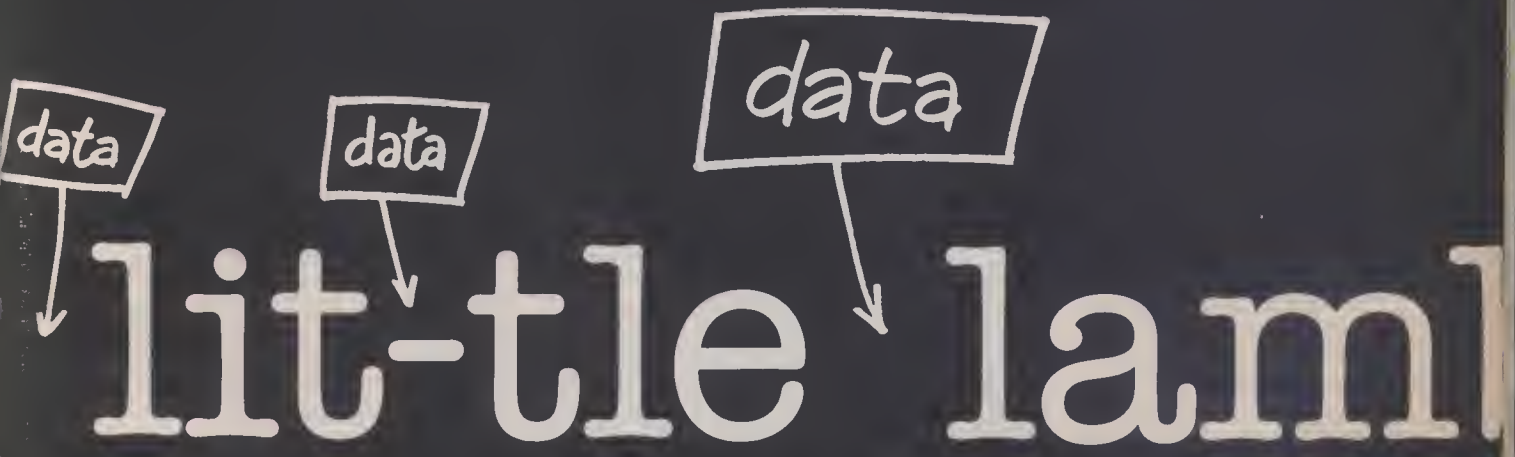
A PCM Frame Switching Concept Leading to Burst Switching Network Architecture, IEEE Communications Magazine, September 1983.

Application of the Burst Switching Technology to the Defense Communications System, Proceedings 1983 IEEE Military Communications Conference, MILCOM '83, Washington, D.C.

Performance Evaluation of a Distributed Burst-Switched Communications System, Proceedings Second Annual Phoenix Conference on Computers and Communications, March 1983.

A Complementary Speech Detection Algorithm, Proceedings of GLOBECOM '83, November 1983.

GTE



In Burst Switching, the roughly 65% silence in speech can be filled with data streams and other messages, effectively tripling transmission capacity.

SYNTHETIC METALS NEAR REALITY

New findings boost hopes of big payoffs for nonmetallic conductors

Lightweight organic compounds with metal-like electrical properties have held out vast technological promise for two decades. Called synthetic metals, or synmetals, they've been proposed as components in compact, high-efficiency electric motors, zero-loss electrical transmission lines, and ultradense supercomputer circuitry. Until recently, however, these goals have been elusive, largely because they require superconductivity—the ability to carry an electric current with near-zero resistance. Several such materials have now been developed, rekindling the hope that synmetals can be put to work in industry.

Synmetals are also interesting for their light weight (typically only about half that of ordinary metals). They might be ideal for spacecraft electronics, for example, and motors using superconducting magnets would be smaller, lighter, and more efficient than present motors.

At least some of these applications now seem to be within striking distance of reality. Although synmetals once had to be cooled to near absolute zero (−273° C) before they became superconducting, researchers have been steadily raising the transition, or critical, temperature—the point at which superconductivity is reached. (Superconducting synmetals are only fair-to-middling conductors above their transition temperatures; at room temperature, they are only about a hundredth as conductive as copper.) In the past three years, those temperatures have risen from −272° to −265° C. And while the latter can hardly be considered balmy, such results "lead you to speculate that it's possible to do much better," says Jack M. Williams, senior chemist at Argonne National Laboratory (Argonne, Ill.).

Progress has also been made in lowering the pressures needed to make synmetals superconducting. While pressures of up to 12,000 atmospheres were once required to produce superconductivity in the chilled materials, recent molecular remodeling has made some of them superconducting at atmospheric pressure.

But transition temperatures will have to rise to at least −243° C to make superconducting synmetals practical alternatives to existing materials. Another problem is brittleness, which makes synmetals hard to fabricate into wires or other useful shapes. And while the current high costs of experimental quantities of synmetals will probably fall as applications blossom, the depth and swiftness of the fall remain uncertain.

Still, most investigators feel that these hurdles will be overcome. "These materials will definitely be used in the next generation of electronic devices," says Dwaine O. Cowan, professor of chemistry at Johns Hopkins University (Baltimore), adding that they will probably make their debut within a decade.

Synmetals are made by combining two different types of compounds. One molecule—usually a flat, organic, ringlike structure containing carbon and either sulfur or selenium—becomes positively charged by giving up its electrons; the other molecule, which can be organic or inorganic, assumes a negative charge by taking up the electrons. Because of this transfer, chemists call the synmetals donor–acceptor or charge-transfer salts.

The result is a series of alternating positive and negative ions (cations and anions, respectively), resembling a stack of pancakes. Conduction takes place primarily in the cations, whose electron orbitals tend to overlap to form an extended channel, known as a valence band, through which electrons can zip up and down the stacks. Superconductivity apparently results because some types of cations can be packed close enough together to allow electrons to move not only vertically but also laterally (from stack to stack).

The first conducting organic charge-transfer salts were made at DuPont around 1960. They consisted of an electron acceptor molecule called 7,7,8,8-tetra-

Argonne's Williams (top) and Hau H. Wang study synmetals' structure with an x-ray diffractometer. Recent synmetals show promise, says Williams, but "it's possible to do better."

ARGONNE

by Gordon Graff

cyano-p-quinodimethane (TCNQ) combined with donors such as the metal cesium. During the 1970s, researchers at Bell Laboratories and elsewhere combined TCNQ with the first of the flat organic donors—a molecule called tetrathiafulvalene (TTF)—and found that the resulting charge-transfer salts were even better conductors than the ones with metallic donors.

Because the conductive properties of synmetals resembled those of certain metal alloys known to become superconductive at low temperatures, many researchers speculated that the charge-transfer compounds should do the same. (Low temperatures promote superconductivity by causing the electrons to pair up and move in parallel, thus eliminating the collisions that cause resistance.) This proved not to be the case with the TTF-TCNQ combination, which for some unknown reason became insulating when it was cooled. But the search for synmetals capable of becoming superconductors spurred an intensive investigation of dozens of combinations of new donors and acceptors.

European researchers found the first superconducting organic material in late 1979: a compound in which the donor was a selenium-containing molecule called tetramethyltetraselenafulvalene (TMTSF) and the acceptor was an anion called phosphorus hexafluoride. This material went superconducting at −272° C and 12,000 atmospheres (a high enough pressure to squeeze the cations closer together). The discovery unleashed a flood of inquiries into other potential superconductors, most of them consisting of TMTSF compounds combined with anions other than phosphorus hexafluoride. In early 1983 a team headed by Edward M. Engler and Richard Greene at IBM's San Jose research center discovered a compound that became superconducting at −271° C and 4000 atmospheres; in this case the donor was a sulfur-containing molecule called *bis*(ethylenedithiolo)tetrathiofulvalene (BEDT-TTF, nicknamed ET), and the acceptor was the anion perrhenate (ReO_4).

The goal now is to create molecules with much higher transition temperatures. While the search has been largely abandoned for what has been called the Holy Grail of synmetals—a room-temperature superconductor—researchers are optimistic about developing synmetals (and metals too) with critical temperatures as high as −232° C. For now, the highest known critical temperature is −249° C, for an alloy of the metals niobium and germanium. A synmetal with a critical temperature of −232° C would almost certainly have practical applications, since liquid hydrogen (−242° C) could be used as a coolant. While hydrogen is not without risk (including the danger of exploding), it is far cheaper and easier to handle than liquid helium (−271° C), which would be needed to chill today's superconducting synmetals.

Two approaches to hydrogen-cooled synmetals are being tried. One consists of new variations on TMTSF and ET, the two families of synmetals that are known to display superconductivity. The other is the study of synmetals with entirely different molecular frameworks, such as carbon-containing rings with the element tellurium built into the structure.

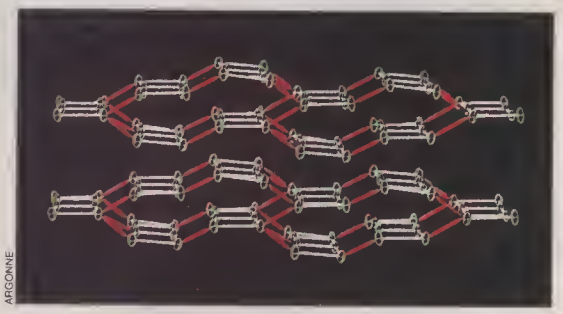
IBM's Engler (left) and Greene display a molecular model of a new synmetal. Their research uses chlorine- and bromine-based photoresists that may lead to more efficient computer-chip production.

Because anion size governs the distance between the cations (and thus the conductivity), one new approach uses smaller anions to minimize the gap. Some of the most intense efforts center on ET; Williams's group at Argonne, for example, has found that an ET derivative with a singly charged iodine- and bromine-containing anion (IBr_2) becomes a superconductor at −270° C and at atmospheric pressure. And Williams says he has recently come across another ET derivative (based on gold and iodine) that goes superconducting at −268° C and atmospheric pressure.

Last year I. F. Shchegelov at the Institute of Chemical Physics in Moscow reported that the triiodide (I_3) derivative of ET has a transition temperature of −265° C, although some applied pressure was needed. Groups at Argonne and Sandia National Laboratory (Albuquerque), as well as in Japan, are also experimenting with the I_3 derivative.

Virtually everyone agrees that the synmetals will have some technological uses, but there are still some unknown variables in the equation—especially cost and brittleness (although

researchers note that certain brittle alloys have been fabricated into wires, coils, and other useful shapes). Nobody is talking about stringing synmetal telephone wires around the country in place of copper, however. The most likely outlets for the synmetals are in specialized applications where they have a distinct advantage over metals. For example, Williams speculates that, because of their light weight, superconducting synmetals might someday be used in the circuitry of space vehicles.



ARGONNE

Synmetal molecules called BEDT-TTF are arranged in stacks, allowing electrons to flow up, down, and sideways. In this model, sulfur atoms are in red, and negatively charged components are in black.

The magnets of electric motors are another potential role for synmetals. While proposed motors made of superconducting metals would weigh only about a quarter as much as conventional motors, one made of a superconducting synmetal would be lighter still. And transmission lines made of superconducting synmetals could boost the efficiency of the national power network, since normal losses due to resistance wouldn't occur even over hundreds of miles of cable. In computers, moreover, the very low heat production of superconducting synmetals could allow circuits of unprecedented density.

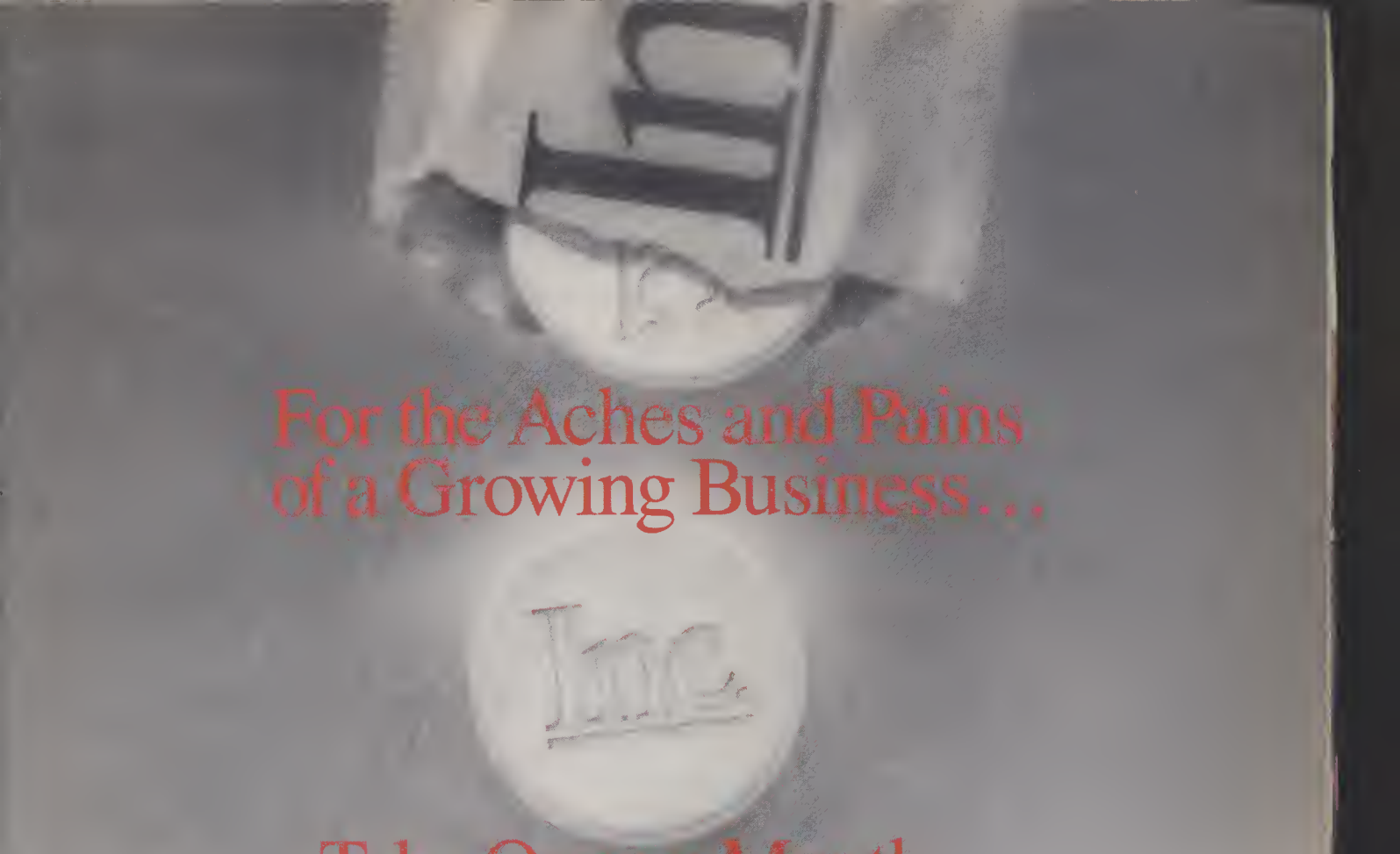
Lightweight superconducting synmetals may one day appear in motors, spacecraft electronics, computers, and transmission lines.

Eventually, the heart of the computer—the memory chips—may be made from synmetals. Already, simple switching devices in which an electric field or light causes regions on a synmetal crystal to shift between two stable resistance states (electrical resistance in two different directions) have been built and patented at Johns Hopkins by Cowan and his former graduate students Richard Potember and Theodore Poehler. The two states, Cowan says, could represent the *0*s and *1*s of computer logic. He envisions the day when thousands of these switching circuits will be fabricated on synmetal crystals. Because the conducting molecular stacks in such crystals could be made to interact, says Cowan, memory storage would be three-dimensional, perhaps leading to memory devices of much larger capacities than those of today's silicon chips, which store information in two dimensions.

Synmetals may also be pressed into service as photoresists to manufacture existing forms of memory chips more efficiently. IBM has experimented with a group of synmetals called TTF halides (chlorides and bromides) as photoresist materials. When an electron beam, programmed to write a specific circuit pattern, is shined on a TTF halide layer deposited on a silicon wafer, the exposed halide decomposes and boils away, leaving behind the etched circuit pattern; the unexposed halide is unaffected. Unlike normal photoresists, of which the exposed portion must usually be washed away, or developed, the IBM process would accomplish the writing and developing in a single step. "We've completed the basic scientific work" on the project, says IBM's Engler (he declines to comment on further plans).

Despite the developmental obstacles, there is a feeling that things are slowly falling into place. "We can hardly jump up and down over what we've done," says Cowan, "but we've nonetheless made real progress." □

Gordon Graff, a New York freelance writer, is a former senior editor of HIGH TECHNOLOGY.



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IT'S A HELICOPTER! IT'S A PLANE!

It's an X-wing, a hybrid aircraft that may change aviation in the next decade

The X-wing configuration will be tested on a Sikorsky S-72 helicopter whose turbofan engines and conventional wings will serve as a backup.

For decades the U.S. Navy has been looking for a utility aircraft that can fly surveillance, search-and-rescue, or resupply missions from the decks of small ships. In the process, it has considered—and rejected—helicopters and vertical takeoff and landing (VTOL) planes. Helicopters are too slow for the Navy's needs, and VTOL aircraft, although fast, don't have sufficient range or payload capacity.

The Navy's dilemma could be an opportunity for a new type of aircraft being developed jointly by NASA and the Defense Advanced Research Projects Agency (DARPA). Called the X-wing, it is similar to a helicopter in that it has a turboshaft-driven four-bladed rotor. Unlike a helicopter, however, the X-wing would be able to stop its rotor in mid-flight to form a fixed wing shaped like an X. The aircraft's engines, decoupled from the rotor, would then drive propulsive fans to enable the X-wing to fly much like a conventional fixed-wing aircraft.

"The X-wing offers the best of both worlds," says James Biggers, head of the rotorcraft division at the Navy's David W. Taylor Research Center (Bethesda, Md.). In its rotary-wing mode, he explains, it would be able to take off and land vertically and hover like a helicopter. And in its fixed-wing mode, the aircraft would be able to circumvent the speed limitations imposed on a helicopter by rotary-wing aerodynamics.

The speed of a conventional helicopter is limited in part by a phenomenon known as retreating blade stall. As the rotor blade continues in its arc around the front of the aircraft, it begins to move aft. During this portion of the arc, the speed of the "retreating blade" through the air is reduced by the forward speed of the aircraft. When the helicopter's speed equals the rotational speed of the tips of the blades, the retreating blade stalls, or loses lift. This phenomenon results in heavy vibrations and control difficulty, requiring the pilot to slow the aircraft.

One way to increase the forward speed would be to increase the rotor speed. But here another limitation comes into play: advancing blade drag. As the rotor blade advances, its speed is effectively increased by the forward motion of the aircraft. When the blade reaches the speed of sound, drag goes up sharply, placing great loads on the rotor as it advances. No one has yet come up with a rotor blade design that has low drag at both supersonic and subsonic speeds—a requisite for making a conventional helicopter fly faster.

The X-wing will overcome the speed barrier simply by stopping its rotor and using the blades as wings at high speeds. It will then be able to cruise much faster than a helicopter, possibly even at supersonic speeds.

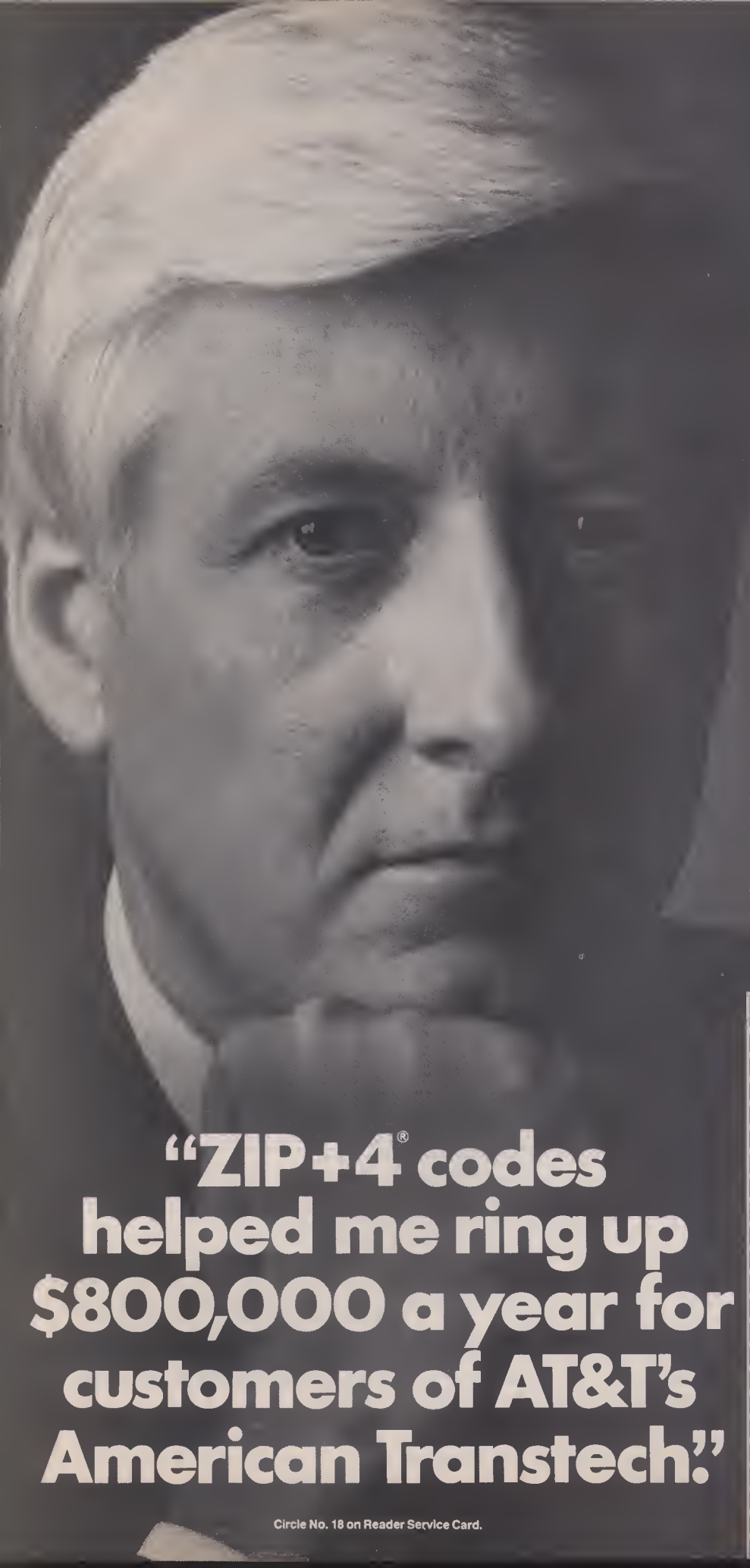
The X-wing will have other impressive capabilities as well. The long, narrow rotor blades will form wings with a high aspect ratio—like those of a high-performance glider—providing high lift and low drag, and hence better cruise efficiency than either a conventional plane or a helicopter. And the high lift of the blades will enable them to support the X-wing without spinning rapidly. As a result, the aircraft will produce minimal downwash when hovering. In most modern helicopters, engines operate at near-maximum speeds at all times; the forward speed of the aircraft is controlled by the position of the blades. But the X-wing, when cruising, will be able to throttle back its engines to a fuel-efficient power setting.

The X-wing will be able to take off and land like a conventional airplane with the rotor locked in position. It may even be able to take off at heavier weights in this manner than as a rotorcraft. Thus a heavily laden X-wing could take off from a long runway and carry supplies to a remote destination. Upon arrival, the weight having been reduced by the fuel consumed en route, the pilot would engage the rotor and land in a small clearing, unload the cargo, and take off vertically for the return trip.

NASA and DARPA are developing the X-wing primarily for its versatility in military applications. Its cruise effi-

by Jeff Richmond

SIKORSKY



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ciency would be ideal for surveillance and reconnaissance missions, and its minimal downwash would be an important advantage in rescue operations and antisubmarine missions that require the deployment of sensitive sonars.

However, the X-wing could have a significant civilian application as well. Combining vertical takeoff and landing with efficient high-speed cruise could result in a new generation of commuter aircraft. For example, X-wings could depart from downtown and then cruise efficiently to a destination 500 miles away in an hour. It is conceivable that an area no larger than a city block could contain all the facilities necessary to support regional and intercity air transportation.

To permit conversion in mid-flight from rotary-wing to fixed-wing mode, the X-wing will employ a rotor of innovative design. The cross section of a conventional rotor blade is similar to the shape of an airplane's wing. It is thick and rounded near the leading edge and tapered toward the trailing edge. The problem with such a design for the X-wing is that when the rotor is stopped, the trailing edge of two of its blades would actually become leading edges.

For this reason the X-wing's rotor will have a symmetrical cross section, with no difference between the leading and trailing edges. An efficient airfoil shape will be achieved by an aerodynamic trick known as air circulation control. In rotary and fixed modes alike, air will be forced through channels in each blade and out through a slot along whichever edge is trailing. The thin film of air exiting this slot induces circulation around the blade, increasing lift.

An electronic "fly-by-wire" flight control system connected to valves located beneath the rotor head will enable the pilot to vary the pressure of the air jets—and hence the lift of the X-wing blades. The pilot will thus be able to control the attitude (pitch and roll) of the aircraft in both rotary-wing and fixed-wing modes. At the same time, the flight control system will automatically vary the lift of the blades to maintain aircraft stability.

An advantage of air circulation control is that it eliminates the intricate mechanics of a conventional rotor. In a normal helicopter the lift of the blades is varied by changing their pitch. This requires a complex mechanical control system that is difficult and expensive to maintain.

NASA plans to employ its Rotor Systems Research Aircraft (RSRA) as a flying test-bed for the X-wing concept. The RSRA (a Sikorsky S-72 helicopter) has conventional fixed wings as well as two turbofan engines for forward thrust, in addition to the turboshaft engines that drive the rotors. Thus it can be flown as a conventional airplane as well as a helicopter—a feature that would permit safe recovery if the X-wing rotor failed in flight.

X-wing commuter aircraft could depart from downtown and then cruise to a destination 500 miles away in an hour

In January 1984, NASA issued a $77 million multi-year contract to Sikorsky Aircraft (Stratford, Conn.), a division of United Technologies, to outfit the RSRA with an X-wing rotor system. According to a Sikorsky spokesperson, the X-wing rotor will probably have been built and mated to the test-bed aircraft before the end of 1986. Initial flight tests are expected shortly thereafter.

If the tests are successful, the next step would be to build a full-scale prototype of an operational X-wing aircraft. The prototype would eliminate the fixed wings of the RSRA vehicle and one set of engines. Instead, it would employ the same engines to drive the rotor in vertical flight and to supply propulsion in fixed-wing mode, using a clutch system to engage and disengage the rotor.

The Navy's Biggers maintains that if development continues at the current pace, a prototype X-wing could be flying by 1991. If a production contract followed soon thereafter, X-wing aircraft could be operating from the decks of most naval vessels by 1995. It is even conceivable that by the late 1990s commercial X-wings could be operating between the downtown areas of major cities in the congested Northeast Corridor. □

Jeff Richmond, who lives in Danbury, Conn., is a freelance writer specializing in aerospace topics.

The U.S. Department of Defense has given two of its four top money-saving awards to Hughes Aircraft Company for proposals that will cut costs by nearly $275 million. The Contractor Value Engineering Achievement Awards honor defense contractors for helping to trim defense costs during 1984. The Air Force cited Hughes for saving $172.8 million on the Imaging Infrared Maverick air-to-surface missile over the life of the contract. The Navy honored the company for reducing projected costs on the UYQ-21 data display system by $101.5 million. Hughes also contributed to the savings achieved by FMC Corporation, which won the Army award for cost-cutting efforts on the Bradley Fighting Vehicle System. The Value Engineering program was created to cut production costs without affecting performance, reliability, quality, maintainability, and safety standards. Last year the armed forces approved 34 Hughes VE proposals for total cost reduction exceeding $296 million. Since 1964, Hughes military customers have approved 705 changes on 52 programs for total savings of $887 million.

International business communications are entering a new era with the advent of direct satellite links. Hughes Communications Carrier Services, a Hughes subsidiary, has been authorized by the Federal Communications Commission to provide International Business Services (IBS) directly through INTELSAT satellites. Ground stations will be established in Brooklyn, Los Angeles, Chicago, and San Francisco to provide service to Europe, Canada, Latin America, and the Far East. Networks will be designed to meet specific corporate requirements, including voice, data, telex facsimile, electronic mail, and video conference services.

A streamlined antenna introduced on a new Mexican communications satellite promises to cut the weight and complexity of future spacecraft. The antenna eliminates potential deployment, structural, and alignment problems associated with multiple-reflector antenna systems on small communications satellites. Morelos, a Hughes HS 376 satellite, has a planar array that acts as a single reflector system operating in both the C- and K-band frequencies. The planar array is a simple beam configuration that has been used for decades on radar systems. On Morelos, the array measures 1½x3 feet and 1 inch thick. It replaces a reflector that would have been about 3x6 feet in size.

For the first time, parts of northern Brazil are receiving telecommunications, thanks to the new Brazilsat communications satellite. The spacecraft brings expanded telephone, television, telex, and data transmission services to all of Brazil. The HS 376 series satellite was built under license from Hughes by Spar Aerospace Ltd. of Canada for EMBRATEL, Brazil's state-owned telecommunications company. As a major subcontractor, Hughes supplied electronic components, mechanisms, and subsystems for the satellite. Brazilsat, launched from an Ariane rocket, is the first HS 376 to operate below the equator, and is therefore inverted or oriented "upside down" in space.

Hughes is seeking experienced engineers and scientists to further develop advanced spacecraft systems and components for communications satellites—successors to the 20 that will have been launched from the space shuttle by 1986. Openings are in the fields of: software, computers, and data processing systems; electrical components; microwave/RF communication systems development; on-board spacecraft electronics and control systems; satellite design, integration, propulsion, and electrical power system development; spacecraft manufacturing, systems test and evaluation; GaAs applications R&D. Send your resume to Dan Frownfelter, Hughes Space & Communications Group, Dept. S2, S4/A300, P.O. Box 92919, Los Angeles, CA 90009. Equal opportunity employer. U.S. citizenship required.

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THE CLINICAL LAB COMES HOME

Diagnostic kits for personal use are reaching the market

Clinical tests that once required the facilities of a hospital laboratory will soon be performed in the home or doctor's office, thanks to a number of self-contained diagnostic kits scheduled to reach the market this year. Although home pregnancy tests and kits for measuring blood-sugar levels in diabetics have been on the market for some time—they accounted for about $165 million in sales last year—the Food and Drug Administration has recently approved several new kits for over-the-counter sale and for use in doctors' offices. They can be used to diagnose common infections, predict ovulation, and measure certain chemicals or drugs in the blood and urine.

The kits, which employ state-of-the-art chemistry and biotechnology—and in some cases advanced microprocessors—are safe, accurate, easy to use, and fairly inexpensive. The Health Industry Manufacturers Association says that many of its 300 member companies are now working on some type of home diagnostic kit. "By the end of the decade, there will be dozens of kits by different manufacturers in a half-billion dollar market," predicts Douglas H. Wallace, author of a recent study for Creative Strategies International (Mountain View, Cal.), a market research firm.

The first home diagnostic kits were designed for insulin-dependent diabetics, who must check their blood-sugar levels several times a day. In 1941, the Ames Division of Miles Laboratories (Elkhart, Ind.) introduced tablets that changed color when dropped into a urine sample containing glucose (blood sugar). Ames later developed more sensitive paper strips that turn a specific color and shade corresponding to the amount of glucose in the blood or urine.

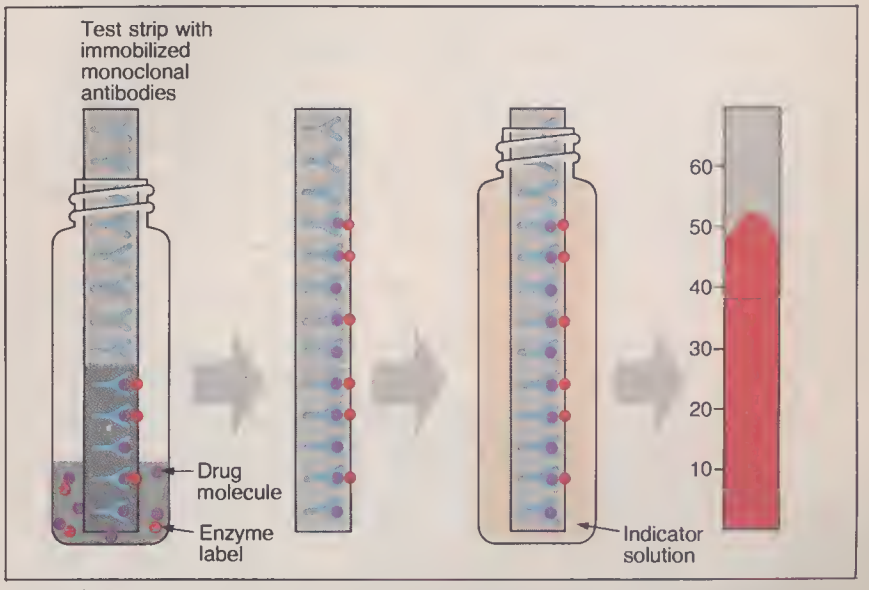
by Robert Zalisk

In 1982, Ames and Bio-Dynamics (Indianapolis) both introduced battery-powered meters that give digital readouts of glucose levels. These devices detect light reflected off the colored reagent strip and convert it into an electrical signal whose strength varies with the color intensity of the strip. This signal is compared with a stored set of calibration values and then converted into a number that can be read on the digital display.

Also on the market in Canada and Europe is an "insulin dosage computer," manufactured by Better Control Medical Computers (Toronto). Designed for diabetics who must take insulin four times daily, the device is based on a modified Hewlett-Packard hand-held computer with 8 kilobytes of memory, and stores five days worth of dosage information. The user measures his blood-glucose level (using a color-changing strip) and enters the reading into the computer, which compares that value with the previous five days of readings and gives the appropriate dosage level for the next insulin injection. The most recent model takes into account three different levels of exercise that the user expects to engage in, and can also operate using urine glucose data.

Another type of home diagnostic kit that has scored a major success is pregnancy tests, which had sales of nearly $50 million last year. The first home pregnancy test was "e.p.t." (early pregnancy test), introduced in 1977 by Warner-Lambert (Morris Plains, N.J.). This kit tested for human chorionic gonadotropin (HCG), a hormone that a woman normally begins to produce after becoming pregnant. The presence of the hormone was revealed through a chemical reaction, resulting in the formation of a dark ring on the surface of the urine sample. But the reaction was very sensitive to vibrations or movement. If the user failed to follow the instructions to leave the specimen in a still place, the ring would be inhibited from forming, producing a false negative.

Last December, Warner-Lambert introduced an improved version of the test that is insensitive to movement or vibration. Called "e.p.t.-plus," it de-



Home diagnostic test measures the concentration of a theraputic drug (theophylline) in the user's blood. A solution containing one drop of blood is allowed to migrate up a paper strip impregnataed with monoclonal antibodies, which have been engineered specifically to bind the drug. The strip is then laced in an indicator solution that causes the bound drug to turn color. The height of the resultin color bar is directly proportional to the concentration of the drug.

tects the target hormone via monoclonal antibodies, proteins secreted by cells that are hybrids of a cancer cell and an antibody-producing cell. Monoclonal antibodies can be produced that will bind specifically to virtually any biological molecule, such as a hormone or an enzyme. The improved pregnancy test is performed by mixing a solution of monoclonal antibodies specific to HCG with a bright red indicator material and then adding three drops of urine. If the urine contains HCG, the monoclonal antibodies will bind to it and cause the red color to lessen. Any decrease in color within two hours indicates pregnancy. According to the manufacturer, the new test has a reliability percentage in the high 90s, the same as clinical laboratory tests.

While "e.p.t.-plus" is effective from the ninth day after a missed menstrual period, Tambrands (Lake Success, N.Y.) recently introduced a kit called First Response/Pregnancy that it claims is effective from the first day. The kit also uses monoclonal antibodies to detect HCG, but the color change is from clear to blue after just 20 minutes. Another monoclonal antibody pregnancy test, called Advance, is produced by Ortho Pharmaceuticals (Raritan, N.J.).

A second type of gynecological test is for predicting the time of ovulation; this test can help in the diagnosis of fertility problems—which affect nearly one out of every five couples—and maximize the probability of conception. Last December, Monoclonal Antibodies (Mountain View, Cal.) began distributing their OvuSTICK kit to doctors' offices and clinics, and it is expected to be available for nonprescription sale in about a year. Like "e.p.t.-plus," OvuSTICK employs monoclonal antibodies to seek out a target substance in a small urine sample. In this case, however, the target is human leutinizing hormone (a surge in the level of this hormone triggers the release of the egg 36 hours later). Tambrands' First Response/Ovulation kit, just now becoming available, works on the same principle. It is the first such kit to receive FDA approval for over-the-counter sales.

Ovaplan, currently under development by Personal Diagnostics (Whippany, N.J.) and Stauffer Chemical (Westport, Conn.), takes a somewhat different approach. The kit consists of a monitor with a memory function and daily disposable test packets, which measure four substances in the saliva that vary with a woman's ovulation cycle: peroxidase, alkaline phosphatase, glucosaminidase, and beta-glucuronidase. Samples of saliva, taken up on a sponge, are analyzed daily, and the monitor reads and stores the results. After a month, the device analyzes the data and suggests a "fertility window" to be sampled during the next menstrual cycle. After three months of data collection, the device identifies a two-day period of peak fertility.

Other types of diagnostic kits look for signs of various diseases. Traces of blood in the stool, for example, are an early indicator of colorectal cancer, of which 130,000 cases are diagnosed each year in the United States. Because early detection is considered vital for effective treatment and cure, Warner-Lambert has developed a kit called Early Detector, which uses "ordinary daily sanitary habits" to collect the stool sample. The kit supplies a specially prepared paper tissue that is used in place of toilet paper and then sprayed with a developer solution. If blood is present, the paper will turn dark purple. Similar tests that require the user to collect a stool sample have been developed by Par Pharmaceuticals (North Saddlebrook, N.J.), C. B. Fleet (Lynchburg, Va.), and SmithKline Beckman (Philadelphia). Because many people are reluctant to handle stool samples, however, Helena Laboratories (Beaumont, Tex.) has developed a kit called Colo-Screen Self-Test, in which an indicator packet is simply dropped into the toilet bowl.

The home diagnostic market is being driven by patients' increasing desire to participate in their own healthcare.

Kits are also being developed to help diagnose infections. A new Ames reagent strip called Microstix Nitrite-3 tests for urinary-tract infections. The kit works by detecting nitrite (a bacterial metabolite) in the urine, which is normally sterile. Personal Diagnostics is developing its own kit. It incubates a small amount of urine in a throwaway test tube and detects clouding caused by bacterial growth by shining a beam of light through the sample medium.

Personal Diagnostics is also working on a test for strep throat, which requires early treatment to prevent the possible development of rheumatic fever. The kit similarly confirms the presence of the target bacteria by detecting clouding. It is expected to give a reading in four hours, versus 24–48 hours for a laboratory test result.

United States Packaging Corp. (La-Porte, Ind.) has developed a gonorrhea test called Gonodecten. It is presently available only for use in doctors' offices but may soon receive FDA approval for over-the-counter sale. The kit employs a chemical called TMPD, which changes from clear to purple when it reacts with the oxidase enzyme complex associated with the gonorrhea bacterium. Results are available in just three minutes, versus 48–72 hours for laboratory tests.

Yet another category of kits determine specific levels of metabolites or therapeutic drugs in the body. This year, Syntex Medical Diagnostics (Palo Alto, Cal.) began marketing a test for determining blood levels of theophylline, a drug commonly used to treat asthma and pulmonary disease. Measuring blood levels of this drug is important because it is effective only within a narrow dose range, and its absorption by the body is affected by a patient's age, weight, diet, and other medications.

The new test requires only a drop of whole blood and uses monoclonal antibodies to measure theophylline levels without instrumentation. First the user pricks his finger to obtain a drop of blood, which is placed in a test tube and mixed with a reagent solution. The reagent solution already contains a set quantity of theophylline molecules that have been labeled with an enzyme. The user inserts into the test tube a cassette that takes up 12 microliters of the solution. This cassette contains a thin strip of paper that has been impregnated uniformly with monoclonal antibodies specific to theophylline. As the sample solution migrates up the strip by capillary action, the free theophylline from the patient's blood and the enzyme-labeled

theophylline bind randomly to the monoclonal antibodies on the strip. The greater the amount of the drug in the patient's blood, the higher up the strip both the labeled and unlabeled theophylline will migrate in order to bind completely (see figure, p. 75).

When the binding step is complete, the cassette is transferred to a second reagent solution containing a substrate, which the enzyme-labeled theophylline converts into an insoluble pigment. The pigment adheres to the strip, revealing the height to which the otherwise invisible theophylline has migrated. This height is directly proportional to the concentration of theophylline in the patient's blood. Since many therapeutic drugs require regular monitoring, the theophylline kit could prove to be a model for others.

At present, the home diagnostic market is being driven by three trends: patients' increasing interest and desire to participate in their own healthcare, the increasing costs of traditional care (particularly in hospitals), and the strong market that existing kits have already established. While routine use of home diagnostic kits may actually increase visits to personal physicians, overall healthcare costs may well decrease because of reduced hospitalization time.

According to market analysts, the market for home diagnostic kits (with the exception of pregnancy tests) is "doctor-driven." As a result, manufacturers are initially marketing many kits for use only under a doctor's supervision. "The kits will first have to convince doctors that they give reliable results and therefore have real utility in treating patients," says Steve Zimmer, an analyst with F. Eberstadt & Company (New York).

Doctors generally have three reservations about the tests: first, that they won't be accurate enough, or that they will be too complicated for many patients to use properly; second, that patients who get false negatives might not seek care until it's too late; and third, that many patients who test themselves may also begin to treat themselves—including those who get false positive results. Nevertheless, the long-term use of home diagnostic tests by diabetics has clearly demonstrated the wisdom of allowing properly educated and motivated patients to participate in their own treatment.

Robert Zalisk is a freelance science journalist who reports regularly for National Public Radio.

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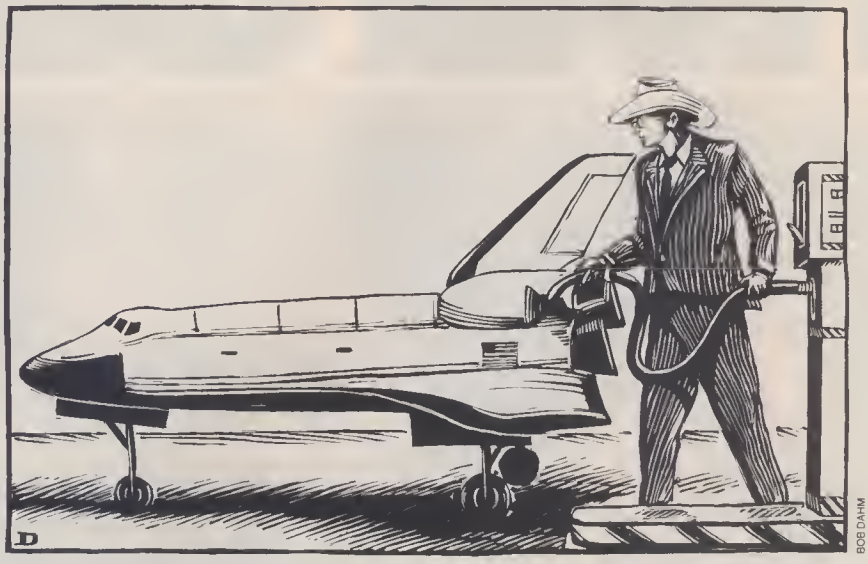
PERSPECTIVES

Houston oil drives space ventures



The Houston business community has launched a drive to turn its area into the U.S. headquarters for space commercialization. This budding industry is expected to constitute a $15-billion-a-year market by the turn of the century, acording to the Center for Space Policy (Cambridge, Mass.). Opportunities include not only traditional aerospace services like building rockets and spacecraft but also space-based manufacturing and satellite scanning to detect subsurface oil and minerals.

Investors in most other communities have shied away from space business because of high costs and the slim chances of near-term profits. "We handle money for widows and retirement funds," says Wolfgang Demisch of First Boston (New York). "Space is too risky." But Houston's investment community was built in large part on perhaps the most speculative undertaking of all—oil exploration—and welcomes such high risks.

Spearheading the effort to make Houston the country's space business capital is a consortium of companies and financial institutions led by the Houston Economic Development Council (HEDC). The city's economy has traditionally depended heavily on oil, gas, and real estate, but recent downturns in these fields drove home the urgency of diversification. Thus the council, formed in 1984, devoted most of its initial funding to studying the economic opportunities of several high tech fields. Space commercialization was chosen because of its potential for long-term growth, says HEDC executive vice-president Andy Rudnick. The proximity of NASA's Johnson Space Flight Center (in Clear Lake, just south of Houston) also influenced the decision.

Rudnick says that space commercialization is still largely misunderstood by many of the high tech companies best positioned to participate. Therefore HEDC's promotional efforts—which began this summer with a $250,000 ad campaign in national business magazines—point out the opportunities for small firms in the design of space station systems and in the use of the Space Shuttle as a factory for electronic materials, pharmaceuticals, and unique alloys.

To make the Houston area more financially conducive to space business, HEDC helped set up a multimillion-dollar R&D limited partnership. The partnership's funds, much of them from oil and gas investors, will go toward creating industrial parks to house small space-related companies. The partnership will also sponsor efforts to transfer commercially viable technology from local universities to interested companies. "We want to bring people together," says Rudnick, "and somehow institutionalize the space business community without bureaucratizing it."

Considerable effort is being made to recruit big companies. The prize catch so far is 3M, which plans to open a facility in the area to support its work on over 70 shuttle flights. But planners also want to "grow their own" space industry with local entrepreneurial talent. Technical staff of the big aerospace companies already in the area are being encouraged to start their own companies. The Clear Lake Economic Development Foundation, for example, is providing business advice to engineers at McDonnell Douglas and Rockwell who have have potentially profitable space ideas, says Stephen Standstadt, the foundation's executive director.

Houston-area entrepreneurs continue to play pioneering roles in space business. In 1981, Space Services raised $6 million in private funds—mostly from oil and real-estate investors—to launch a rocket. And this summer NASA entered into an agreement with Space Industries (Clear Lake), allowing the company to build and operate an unmanned space platform that could be leased by other firms to manufacture products in space. "There is no doubt that in the last few years Houston's financial institutions have acquired a greater understanding of space operations," says Space Industries president Max Faget, formerly a chief engineer in the Apollo program. "Texas investors are used to being rich, and they want to get in on the ground floor of this new industry." □ ***—Jeffrey Manber***

Controversy swirls around experimental aircraft

Is the Right Stuff due for a renewal? A proposed program of experimental aircraft would spend $1 billion a year to build more planes like the X-29—an aircraft that resembles a fighter and has a distinctive forward-swept wing,

as well as a number of other aeronautical innovations. The new generation of X-series aircraft was called for last year by Robert S. Cooper, then head of the Defense Advanced Research Projects Agency (DARPA). But the idea is now running into opposition from critics who say that test planes offer little that can't be learned in less expensive ways.

Not surprisingly, Cooper's plans were met with enthusiasm by some of the big aerospace contractors. "There would be nothing like an experimental aircraft program to make leaps forward in a short period of time," says Bastian Hello, president of Rockwell International's aircraft division (El Segundo, Cal.). "We'd be back in the days of the X-1 and X-2." These were two of the pioneering planes flown by Chuck Yeager and other test pilots in the 1940s and 1950s, when aviation was advancing rapidly.

But others in the aviation community question the need for such a program. "We already have a stable of experimental aircraft," says William Aiken, director for aeronautics at NASA, who contends that aeronautical innovations such as new wings, electronic controls, or propulsion systems can be flight-tested by modifying existing commercial planes. For instance, a promising method of reducing drag is to suck air through numerous small holes in a wing's surface. This technique has been studied extensively in wind tunnels and is now being flight-tested on a modified Lockheed Jetstar. A key question, which is difficult to answer any other way, is whether bugs and dirt will clog the holes.

John Swihart, a vice-president at Boeing (Seattle), notes the increasing role of aerodynamic simulations on supercomputers. By solving appropriate equations, the computer simulates the flow of air past a wing or aircraft shape. And Maurice Roesch, an aeronautics specialist in the White House's Office of Science and Technology Policy, points to the advanced ground-test facilities for engines at NASA's Lewis Research Center.

Swihart—along with Jack Kerrebrock, until recently deputy director of NASA's aeronautics branch—argues that the small number of surprises uncovered in flight testing do not justify the huge cost and that there will be even less to learn from flight testing as simulation methods improve. Kerrebrock, now chairman of MIT's aeronautics and astronautics department, also fears that in a time of budgetary cutbacks a major experimental aircraft program would crowd out less glamorous aeronautical activities. Congress, he says, can "perceive the charm of an experimental aircraft program more readily than that of a more basic research effort."

The X-29 in flight: Are such test planes worth their enormous cost?

Boeing expects to build its forthcoming generations of commercial jets on the basis of such research, without test planes, according to Swihart. The 150-passenger plane Boeing hopes to roll out in 1992 will feature low-drag airfoils, extensive use of composite materials, advanced electronics and controls, and an advanced turboprop engine, all combining to give it twice the fuel efficiency of today's similarly sized 757. "It's very difficult to show that there is enough new technology generated from experimental aircraft to warrant the cost," says Swihart.

There are limitations to ground testing, of course. Wind tunnels cannot accommodate maneuvering aircraft; a fighter pulling 8 g's in a tight turn experiences different conditions from one strapped into place at the same angle. Moreover, existing computational methods cannot capture the full complexity of airflow over an airplane.

Still, it is unlikely that new experimental aircraft will take to the sky until the next decade. So far, Cooper's proposal has generated more talk than action; DARPA did not include an X-series program in its fiscal 1986 budget request. If there are to be successors to the X-29, a consensus must first emerge that the less expensive alternatives are inadequate. Today, no such consensus is in sight. □

—T. A. Heppenheimer

Cancer treatments made to order

One of cancer's most distinguishing features—and one that makes it so hard to treat—is that malignant cells may vary in some way from patient to patient, even among those with the same clinical form of the disease. Yet most therapists tend to treat cancer as though it were perfectly uniform. "Standard medicine still considers one

lung tumor the same as another lung tumor," says Robert K. Oldham, formerly director of medical oncology at Vanderbilt University and now chairman of Biotherapeutics (Franklin, Tenn.). "We're trying to change the way cancer is treated in this country."

The company's researchers are moving toward that goal by designing individualized cancer therapies based on cancer patients' cellular uniqueness. Biotherapeutics, formed in early 1985, is now working with 15 patients—all willing to fund the research leading to the treatments.

The company's related clinical facilities assess the efficiency of the three standard cancer therapies—radiation, surgery, and drugs—according to company president Louis P. Berneman. Unlike most other oncology centers, however, Biotherapeutics emphasizes what it terms the "fourth modality" of cancer treatment: biologicals, or largely experimental tumor-killing substances that are produced in small amounts by mammalian cells.

Much of the technology stems from a current National Cancer Institute (NCI) biologicals research program that Oldham designed and led for four years. While these substances are also being studied by other research groups, and have recently been assigned high priority status by NCI director Vincent DeVita, Biotherapeutics appears to be the first firm to employ them in individualized treatment.

Biotherapeutics' treatment strategies now hinge on biologicals called monoclonal antibodies—cell-killing proteins that are secreted by the immune system against foreign substances, including cancer cells. Therapies based on other biologicals, such as interferon and tumor necrosis factor, are also being researched. The monoclonal antibodies are produced in mice by injecting the animals with the patient's tumor cells. Certain of the animals' white blood cells soon respond to the invasion by producing antibodies that recognize and selectively attack the patient's structurally unique cancer cell. The mouse's antibody-producing cells are then extracted and fused with a "store-bought" cancer cell (called a myeloma) to form a new and long-lived hybrid cell that turns out large amounts of antibody against the original tumor cell.

All patients entering the Biotherapeutics program first undergo a "tumor acquisition and processing stage," at a cost of $1500; a sample of the tumor is expanded in tissue culture and in nude mice (a specially bred strain of hairless animals whose immune systems are unable to reject the tumor cells). The cells are then tested with known anticancer therapies to determine susceptibility. For example, "it's possible that a tumor will respond to a particular combination of conventional drugs," says Oldham. "In that case, we will advise the patient's private physician so he can administer the treatment." The firm also stores part of the tumor in liquid nitrogen for future testing and reference.

Once the tumor has been characterized, the patient may opt for a research program to develop a custom antibody therapy (at a cost of $32,900). The treatments are administered in clinical facilities working with Biotherapeutics and are based on antibodies or immunoconjugates (antibodies that are chemically coupled to a drug or radioisotope). As the molecules circulate through the patient, they selectively seek out and bind to the malignant cells against which they were grown; these cells are destroyed either by the unconjugated antibody or by the attached toxic material. This selective assault may reduce or eliminate the debilitating side effects—including hair loss, severe nausea, and in some cases kidney damage—caused by conventional chemotherapy, which kills normal as well as cancerous cells.

Oldham expects that it could require between three and ten different types of antibody, combined into an injectable "cocktail," to fully treat a patient. One reason is that cancer cells often raise "decoys" against an antibody by mutating during proliferation, thereby changing their physical and chemical profiles.

Although Biotherapeutics' treatments are individually designed, many antibodies appear to attack more than one type of tumor cell. Several hundred such proteins have been identified, in fact, and many of them are now undergoing clinical trials around the country. Therefore, as each new antibody is created by Biotherapeutics (or acquired from other researchers), a portion of it is cryogenically preserved by the company for future treatments. "We will one day have what amounts to a whole shelf full of antibodies and other biologicals," says Oldham. "That will give us a tremendous selection of ready-made therapies to test against new tumor samples."

Biotherapeutics accepts only about a tenth of the patients who apply. The rest are considered medically inappropriate, usually because they can be cured by conventional treatment or because the disease is too advanced. "It requires six months or more to design a therapy," says Oldham, "during which time we need a close doctor–patient relationship. So we'll want patients who can work with us for at least that period of time." Another limitation is that cancer therapy based on biologicals is presently classified as experimental, so Biotherapeutics' research fees are not covered by Medicare or most private health insurance policies.

The company's formation during late 1984 and early 1985 provides something of a lesson in down-home resourcefulness. "We had originally wanted to raise $2.1 million through private venture capital," says Berneman, "but that could have cost us up to 25% in expenses such as fees and commissions. So we held a series of meetings around the country, secured about 70 private and corporate shareholders, and wound up with $3 million—at a cost of 1.5%."

For Biotherapeutics to pay off for its investors, says Berneman, "we have to prove not only that our methods are technologically and clinically sound but also that we have a valid marketing approach." But another company goal, says Oldham, is simply to get its message of individualized cancer treatment out to where it can be heard. "We think that biologicals are going to be an irresistible force in the next generation of cancer therapies." □

—H. Garrett DeYoung

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Inst. of Computer Science and Technology, National Bureau of Standards, Gaithersburg, MD 20899, (301) 921–2731. Center for computer and network technologies.

IEEE Computer Society, 1109 Spring St., #300, Silver Spring, MD 20910, (301) 589–8142.

Seybold Publications Inc., Box 644, Media, PA 19063, (215) 565–2480. Publisher of the *Seybold Report on Professional Computing*. $195/year.

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TECHSTARTS

Galactic Resources:
THERE'S STILL GOLD IN THEM THAR HILLS

A new gold rush may be starting this year in the same Colorado Rockies sites that an earlier generation of prospectors had thought were played out. What's different today is a technique called heap leaching, in which a highly diluted cyanide solution trickles through piles of low-grade ore to remove gold that was previously unprofitable to extract. The technique can produce gold at half the cost of conventional mining because it makes smelting unnecessary and utilizes ore that can be uncovered through relatively low-cost strip mining. Galactic Resources is one of a handful of small companies—and a few larger ones, such as Newmont Mining and Alma American Milling—that plan to reopen abandoned mines to set up heap-leaching operations. Galactic expects its Summitville, Colo., mine, being built by Bechtel with $25 million from the Bank of America Canada, to be fully operational in May 1986.

Financing: $10.5 million (Canadian) from three public stock offerings. The U.S. OTC listing is GALCFQ.

Management: Founder, chairman, and CEO Robert Friedland founded a nonprofit organization to combat blindness in Nepal and previously ran an apple orchard in Portland, Ore., in partnership with Steven Jobs (who went on to cofound Apple Computer). President and COO Edward Roper was general manager of Pegasus Gold, another heap-leaching mining company.

Location: 355 Burrard St., Suite 935, Vancouver, B.C., Canada V6C 2GB, (604) 687–7169.

Founded: October 1982.

Galatic Resources chairman Robert Friedland has his eye on long-abandoned gold ore deposits.

Artel Communications:
OPTICAL FIBERS FOR SENDING IMAGES FASTER

A picture may save a thousand words, but when it comes to transmitting electronically produced pictures—whether made by video cameras or by computer-aided design (CAD) systems—they can easily consume a thousand times more bandwidth than mere text. That's why the extremely high transmission capacity of fiber optic cable (which transmits pulses of light rather than electrical charges) is so useful for high-speed communication of images. Artel Communications makes fiber optic links for video systems—used by commercial TV broadcasters and the military—and links for CAD systems that require high-speed communication between host computers and far-removed workstations. Because most competition in fiber optics is taking place in telecommunications, Artel has its market niche practically to itself.

Financing: $6.3 million from a June 1983 initial public offering of 1.2 million shares of stock at $6 per share, underwritten by Rooney, Pace Inc. OTC stock symbol is AXXX.

Management: The two founders, Tadeusz Witkowicz and Richard Cerny, came from the fiber optic communication division of Valtec, a manufacturer of fiber optic cable. Witkowicz, who is chairman, president and CEO, was manager of electronics research and developments. Cerny, a director, was head of marketing.

Location: 93 Grand St., Worcester, MA 01610, (617) 752–5690.

Founded: March 1981.

Rational:
SIMPLIFYING SOFTWARE DEVELOPMENT

Large-scale software systems for projects like the Space Shuttle can be of mind-boggling complexity; some take years to complete and involve hundreds of programmers. And once the programs are up and running, maintaining and modifying them in the face of innumerable changes can be if anything—even more complicated. Rational's solution is a software development system that automatically breaks large projects into smaller modules, which it then tracks through initial programming, integration, and eventual modification. Based on the programming language Ada, the system runs on a special-purpose multiuser computer. Rational's target markets are aerospace and defense contractors—it already has a contract with Lockheed—and other private-sector companies that have large-scale computerized operations, such as automated factories. Although a number of computer manufacturers and software houses sell development tools for Ada programming, none has a whole system in direct competition with Rational's.

Financing: $35.8 million in venture capital financing from investors including Arthur Rock, Hambrecht & Quist, and Lockheed.

Management: Founders Paul Levy and Michael Devlin were software designers for the Air Force's satellite control facility in Sunnyvale, Cal. Levy, president and CEO, headed several large software development projects for the U.S. space program; Devlin, executive VP, was a program manager and liaison to the Defense Advanced Research Project Agency (DARPA) regarding software methodologies. James Barth, VP of finance, was senior VP in charge of finance for Magnuson Computer Systems.

Location: 1501 Salado Dr., Mountain View, CA 94043, (415) 494-2030.

Founded: December 1980.

ORTHOPEDICS WILL SEE LONG-TERM GROWTH

An older, more athletic society fuels demand

Orthopedic devices play a significant role in surgical procedures for treating such problems as arthritis, broken bones, and torn ligaments. The market for such equipment should reach $1 billion this year and is growing at an annual rate of about 10%, according to Biomedical Business International (Tustin, Cal.).

Two social trends are driving this market: The U.S. is becoming an increasingly elderly nation, with nearly 14% of the population expected to be 65 years or older by the turn of the century, and a growing number of people are participating in physical activities. An older and more active population is more vulnerable to problems caused by sports-related accidents or by degenerative bone diseases such as arthritis and osteoporosis (brittle bones).

Three segments of the orthopedic device market are particularly affected by technological advances. One of these is hip-joint replacements, a $300 million annual market. The loosening of artificial hips five to ten years after implantation has spurred the development of joints coated with a porous metal powder that enables bone tissue to adhere more quickly and with less chance of rejection. Such devices currently represent a small portion of the total hip-joint market, but are expected to account for most of a $450 million market in 1990.

Noninvasive electrical bone healing is another growing market. This technique is based on the fact that bone formation can be induced by small electric currents, thus avoiding bone-grafting surgery for fractures that do not mend spontaneously. These currents can be generated by low-energy, pulsed electromagnetic devices. In recent years this equipment has been miniaturized to the point where battery-powered portable versions can be attached to a cast. The annual purchase and rental market for such bone-growth stimulators is $50 million and should reach $80 million by 1990.

The third segment involves continuous passive motion (CPM) equipment for orthopedic rehabilitation therapy. Traditional treatment has been to immobilize a joint following the operation, but physicians are now showing interest in CPM devices that mimic a joint's natural bending ability. By "exercising" a joint following surgery, such equipment prevents scar-tissue formation, speeds healing, and enhances use of the injured limb—which, in turn, means a shorter hospital stay. The CPM market should reach $27 million this year, climbing to $100 million by 1990.

Two thirds of the orthopedic market is dominated by divisions of large, diversified healthcare firms. Among second-tier firms, three are particularly well positioned to offer products in the aforementioned segments: Stryker (Kalamazoo, Mich.), Electro-Biology (Fairfield, N.J.), and Smith Laboratories (Northbrook, Ill.)

Stryker (OTC: STRY) offers products in most orthopedic markets, including closed-wound drainage systems, artificial ligaments, surgical instruments, and specialty beds. Its strong sales and marketing program has enabled the company to maintain a 20% annual growth rate despite cost-containment pressures affecting all hospitals and their suppliers. A key role in Stryker's future growth will be played by its Osteonics division, which is marketing a coated hip prosthesis. Early this year, Stryker also introduced a line of artificial hips with interchangeable bearings that enable the physician to put together the best fit for a patient. The company expects to introduce an artificial knee in 1986.

Stryker is projected to reach $100 million in sales in 1985, with profits of $9 million and $1.70 earnings per share, up from 1984 revenues of $84 million, profits of $6.9 million, and earnings of $1.40 per share.

Electro-Biology (OTC: EBII) is the leading company in noninvasive bone-growth stimulators. After several years of rapid growth, Electro-Biology's stimulator sales have flattened, an indication that the 20,000 devices currently in use may represent a temporary saturation level. The company is confronting this slowdown by pursuing additional bone, tissue, and nerve augmentation applications in osteoporosis, loosened-joint implants, and tendon repair, which use technology similar to that in electrical bone stimulators. Moreover, Electro-Biology recently entered the fast-growing market for noninvasive scoliosis therapy with an electrical device that can correct abnormal curvature of the spine.

Profits in 1984 were $3.6 million based on revenues of $27.8 million, with earnings per share of 62¢. Biomedical Business International estimates $4.2 million net earnings in 1985, based on revenues of $32 million. Earnings per share should be 80¢.

Smith Laboratories (OTC: SMLB) has experienced a serious loss in sales of its principal product, Chymodiactin, a drug used to treat patients with herniated discs. Initial results were disappointing because the drug's complex administration procedure was not yet well established. However, prospects for the company could improve as a result of acquiring Sutter Biomedical in January 1985, which will make Smith one of the leading contenders in the CPM market. Sutter is known for its innovative product development and marketing, having introduced the first CPM unit tailored for home use and the first device to integrate CPM equipment with a neuromuscular stimulator. The latter prevents muscles from weakening while the patient's joint is healing.

In 1984 Smith's net income was $5.7 million, sales were $23 million, and the stock earned 42¢ per share. As a result of the slowdown in Chymodiactin use, these figures are expected to drop in 1985 to a net income loss of $500,000, sales of $15 million, and a loss per share of 3¢. □

by Pieter Halter

Pieter Halter is president of Biomedical Business International, a healthcare information services and market research firm based in Tustin, Cal.

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